

# Groundwater and Well Water

## St. Croix County

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Center for Watershed Science and Education



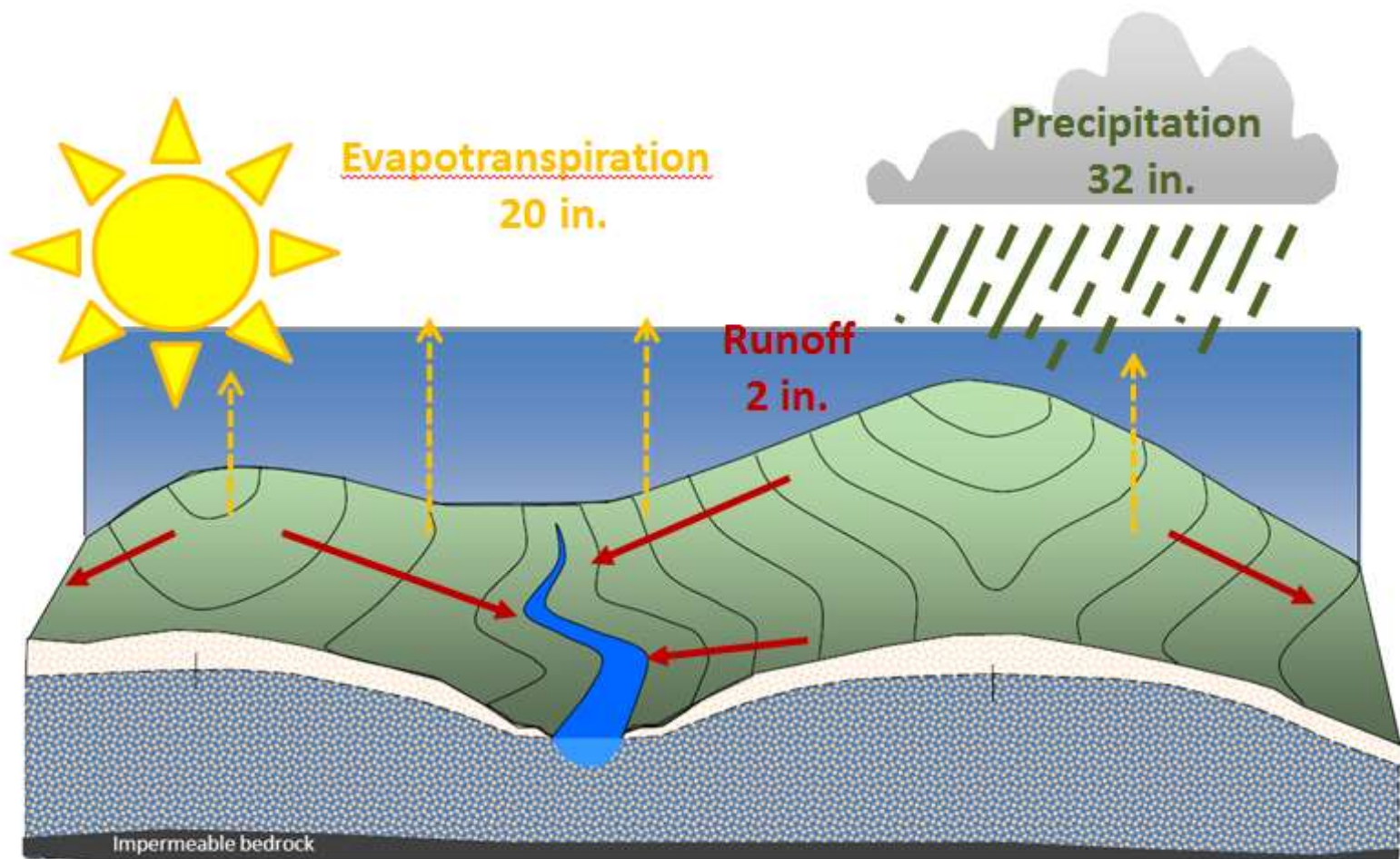
**University of Wisconsin-Stevens Point**  
College of Natural Resources

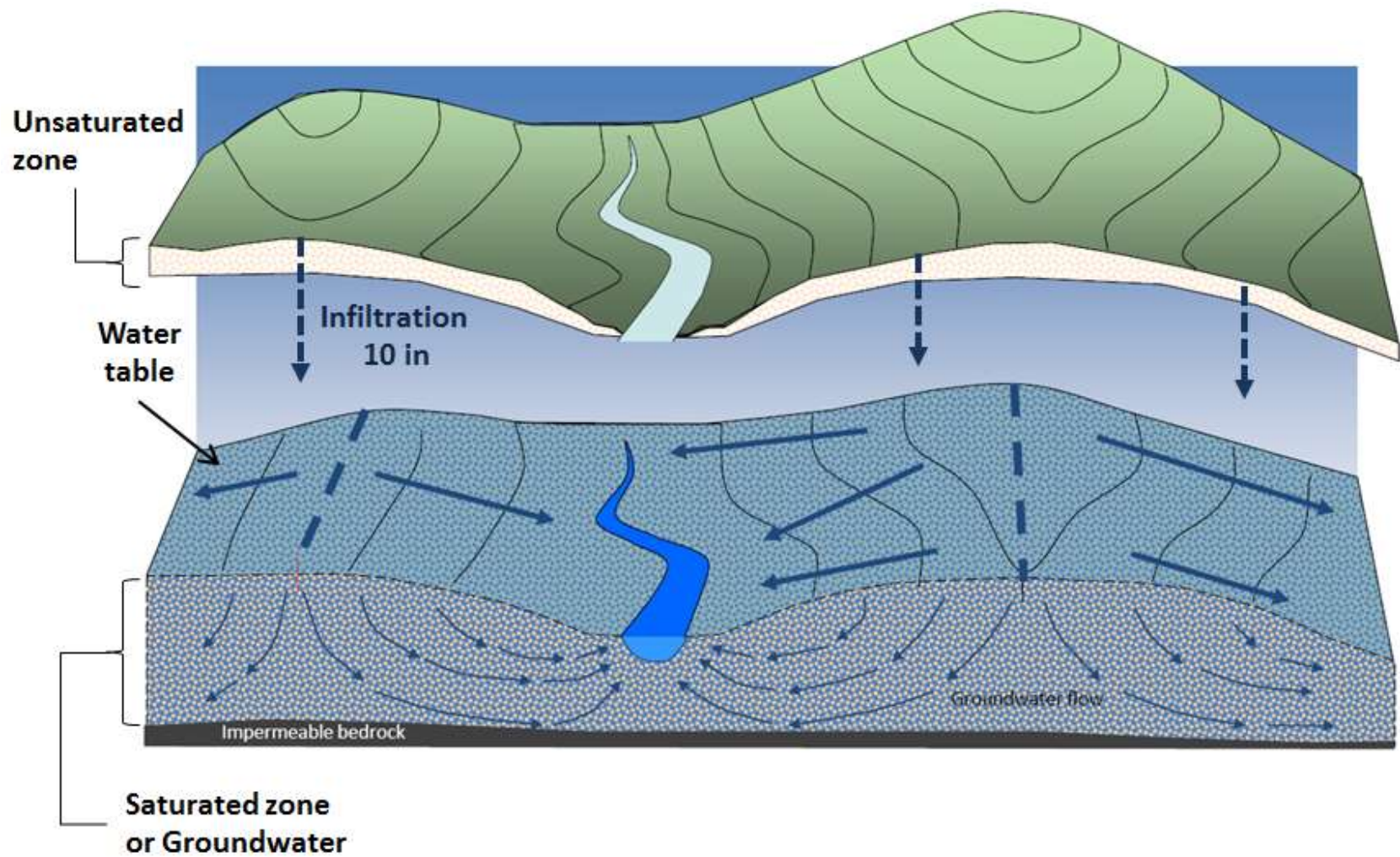
Through the University of Wisconsin-Extension, all Wisconsin people can access University resources and engage in lifelong learning, wherever they live and work.

# Today's presentation

- Groundwater Basics
- General groundwater quality in St. Croix County
- Factors affecting groundwater quality

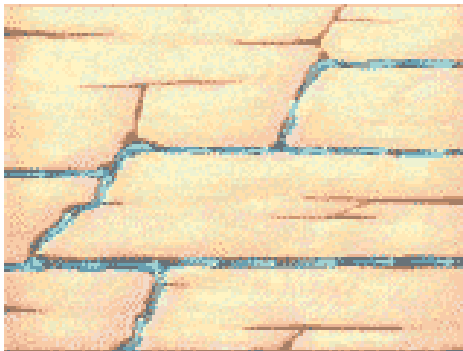
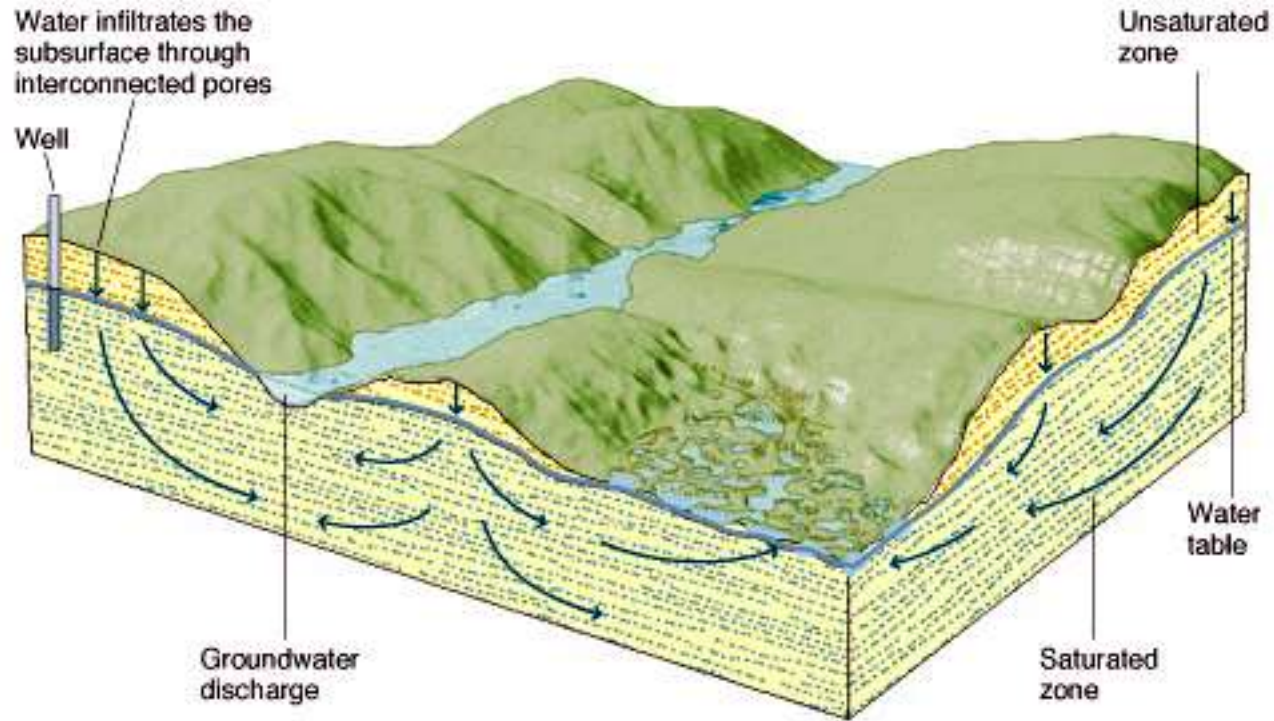








# Groundwater Movement

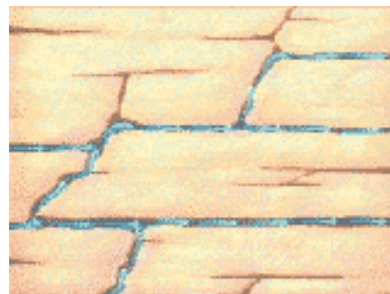


# Aquifers: Our groundwater storage units

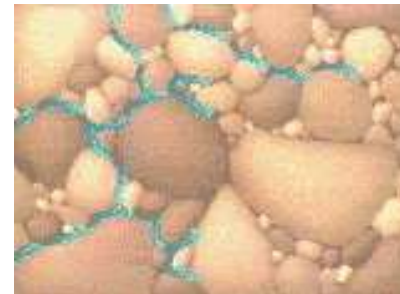
Aquifers are geologic formations that store and transmit groundwater.

The aquifer properties determine how quickly groundwater flows, how much water an aquifer can hold and how easily groundwater can become contaminated. Some aquifers may also contain naturally occurring elements that make water unsafe.

Wisconsin's geology is like a layered cake. Underneath all of Wisconsin lies the Crystalline bedrock which does not hold much water. Think of this layer like the foundation of your house. All groundwater sits on top of this foundation. Groundwater is stored in the various **sandstone**, **dolomite** and **sand/gravel** aquifers above the **crystalline bedrock** layer. The layers are arranged in the order which they formed, oldest on the bottom and youngest on top.



Water and contaminants can move quickly through cracks and fractures.



Water moving through tiny spaces in between sand particles or sandstone moves slower and allows for filtration of some contaminants.

Learn more about Wisconsin's geologic past by clicking the aquifer names

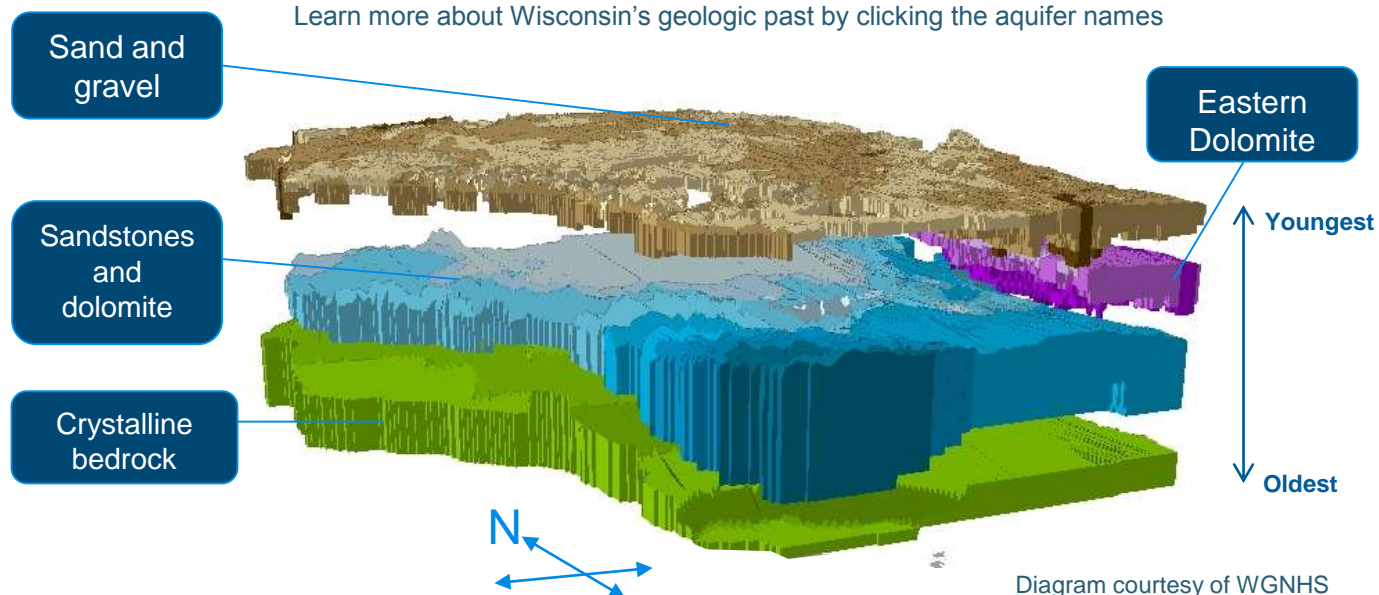
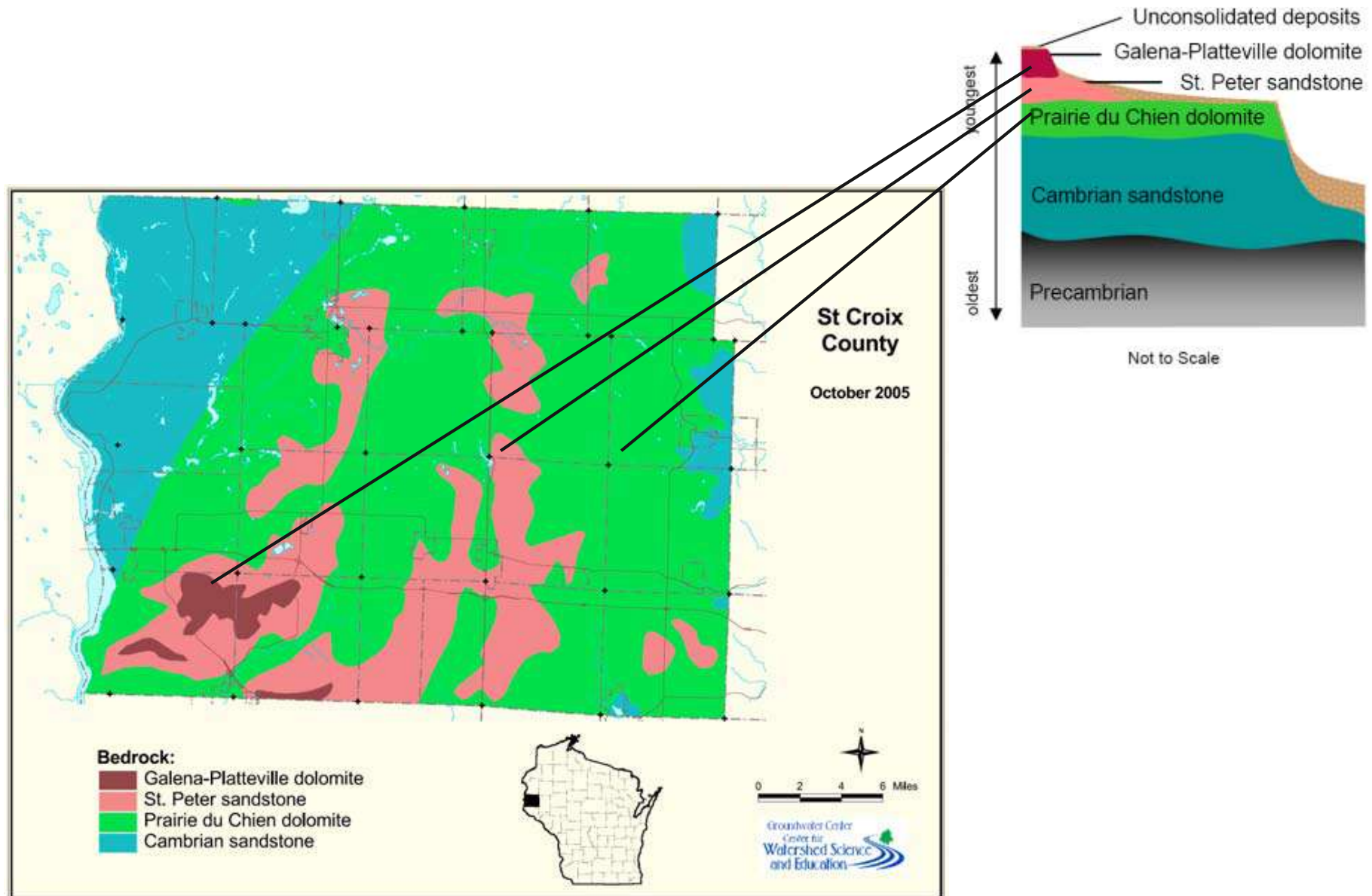


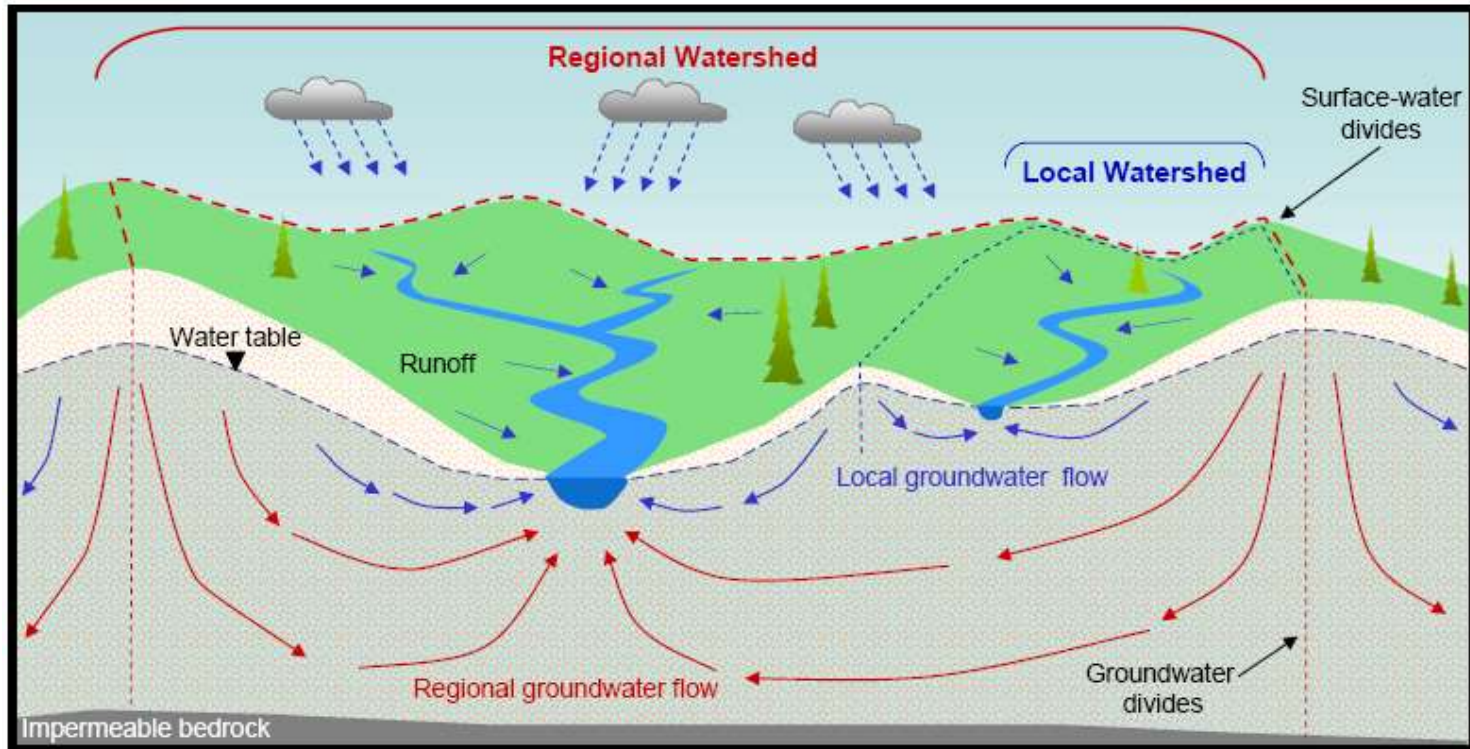
Diagram courtesy of WGNHS

# St. Croix Bedrock Geology





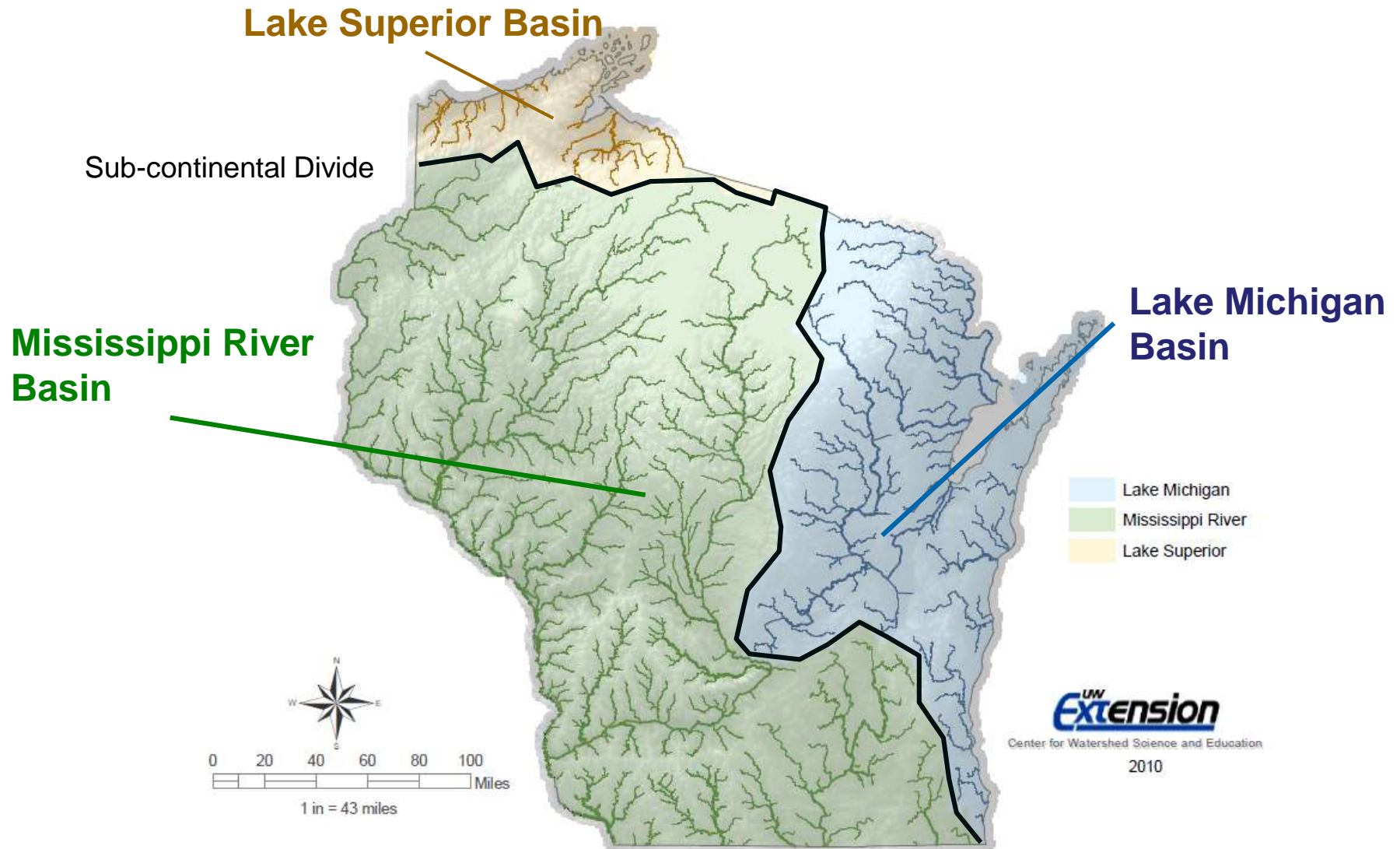
# How do we know where our groundwater comes from?



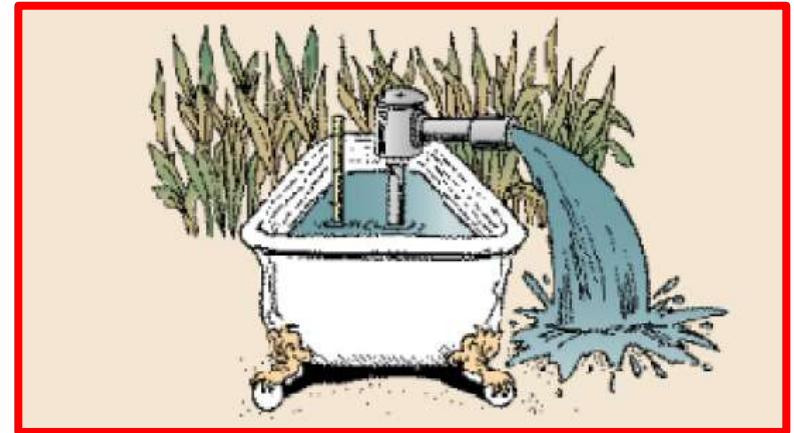
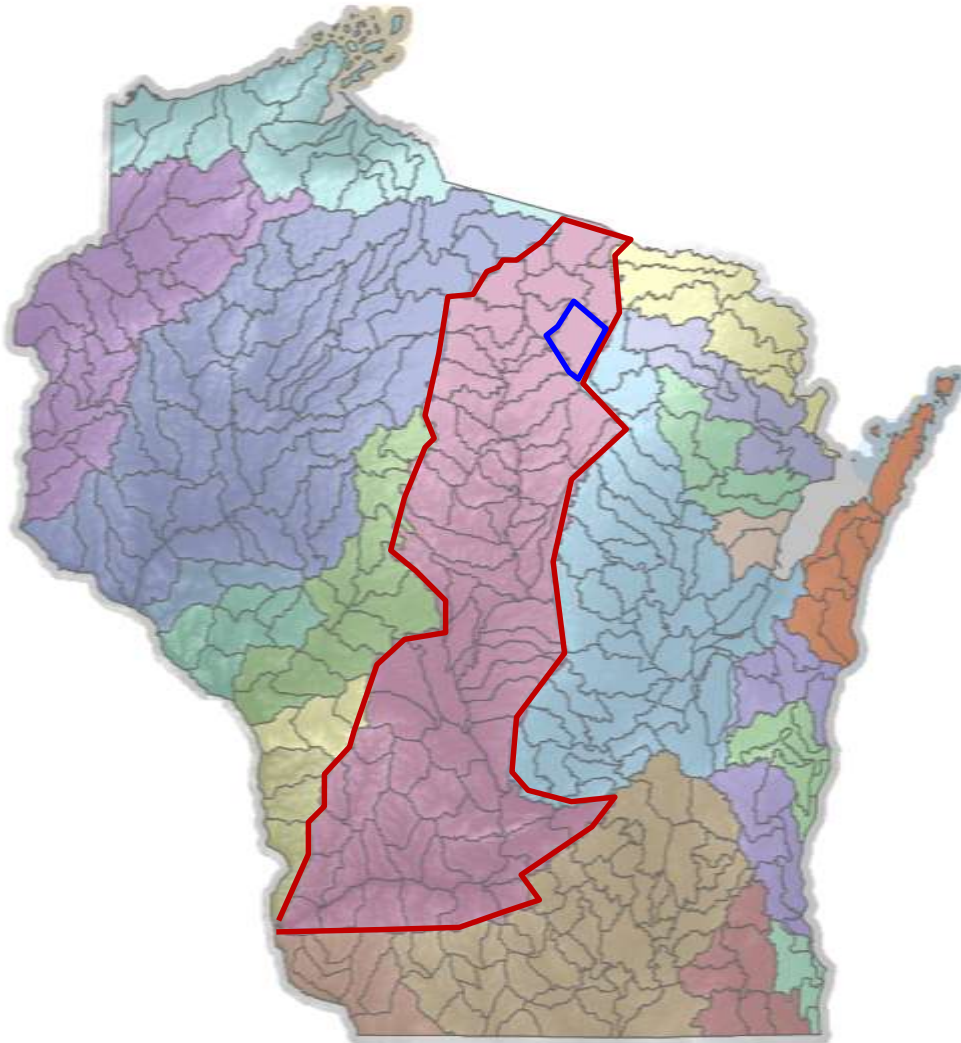
**Watershed** – the land area where water originates for lakes, rivers or streams. Water flows from high energy to low energy.



# Wisconsin has 3 major basins



....regional watersheds can be further defined to show just how local groundwater quality really is.



<http://pubs.usgs.gov/circ/circ1186/pdf/circ1186.pdf>



# Groundwater Movement in St. Croix County

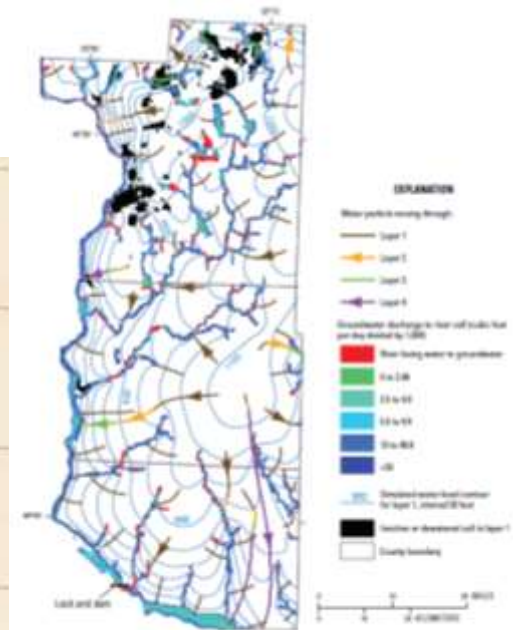
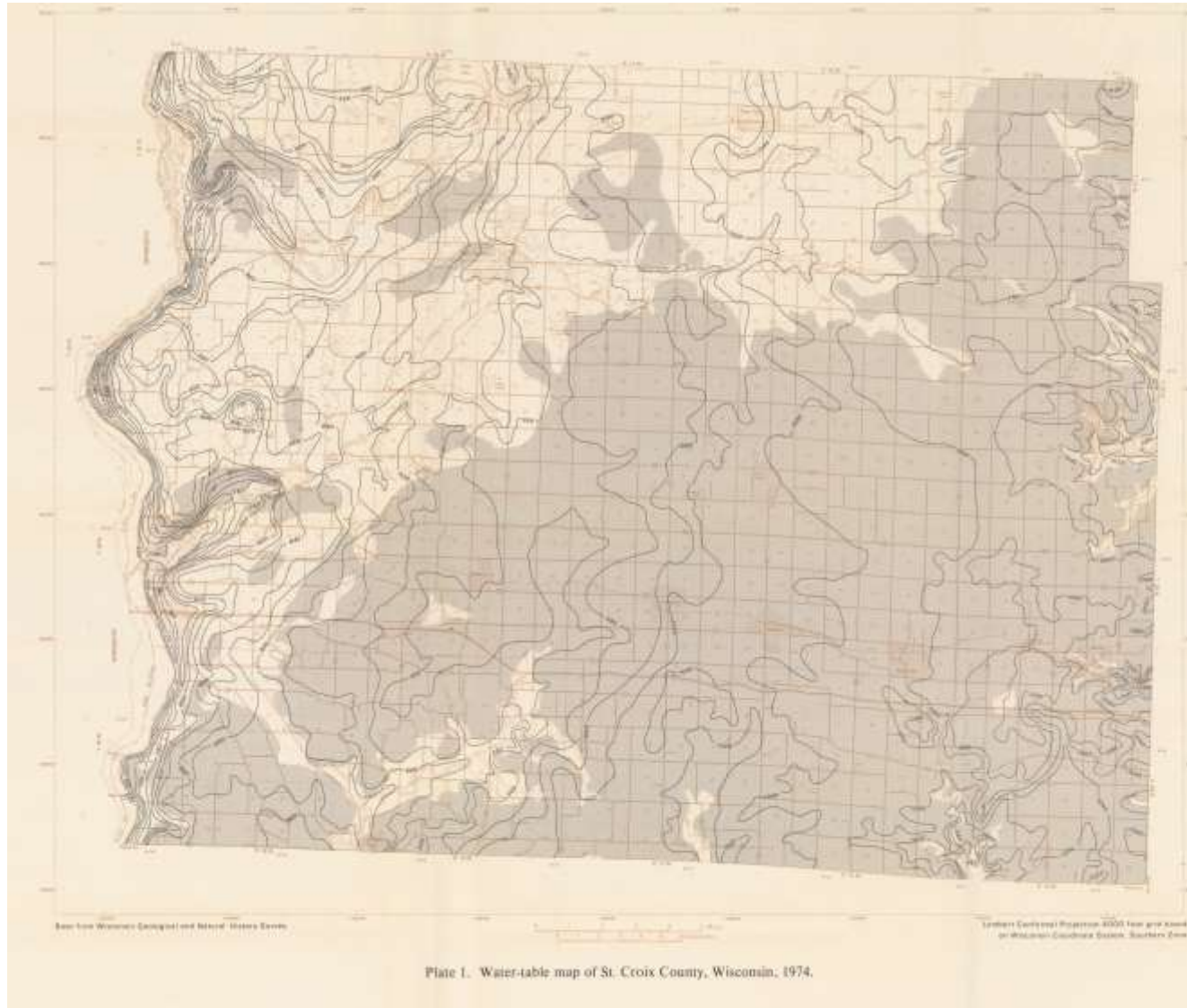
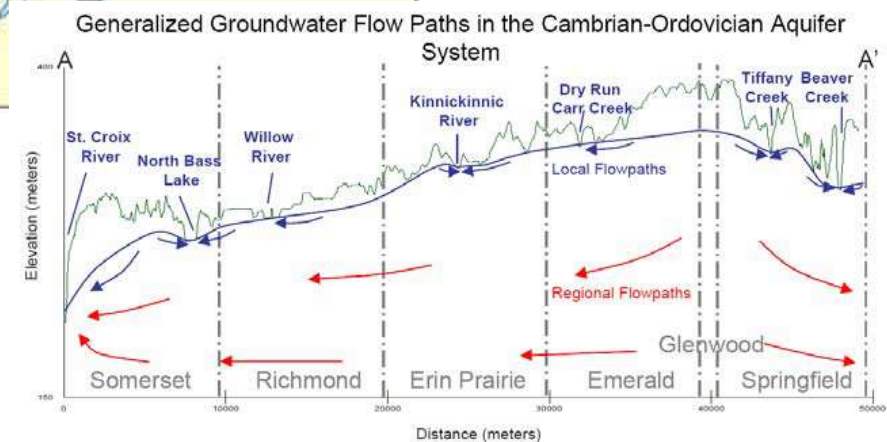
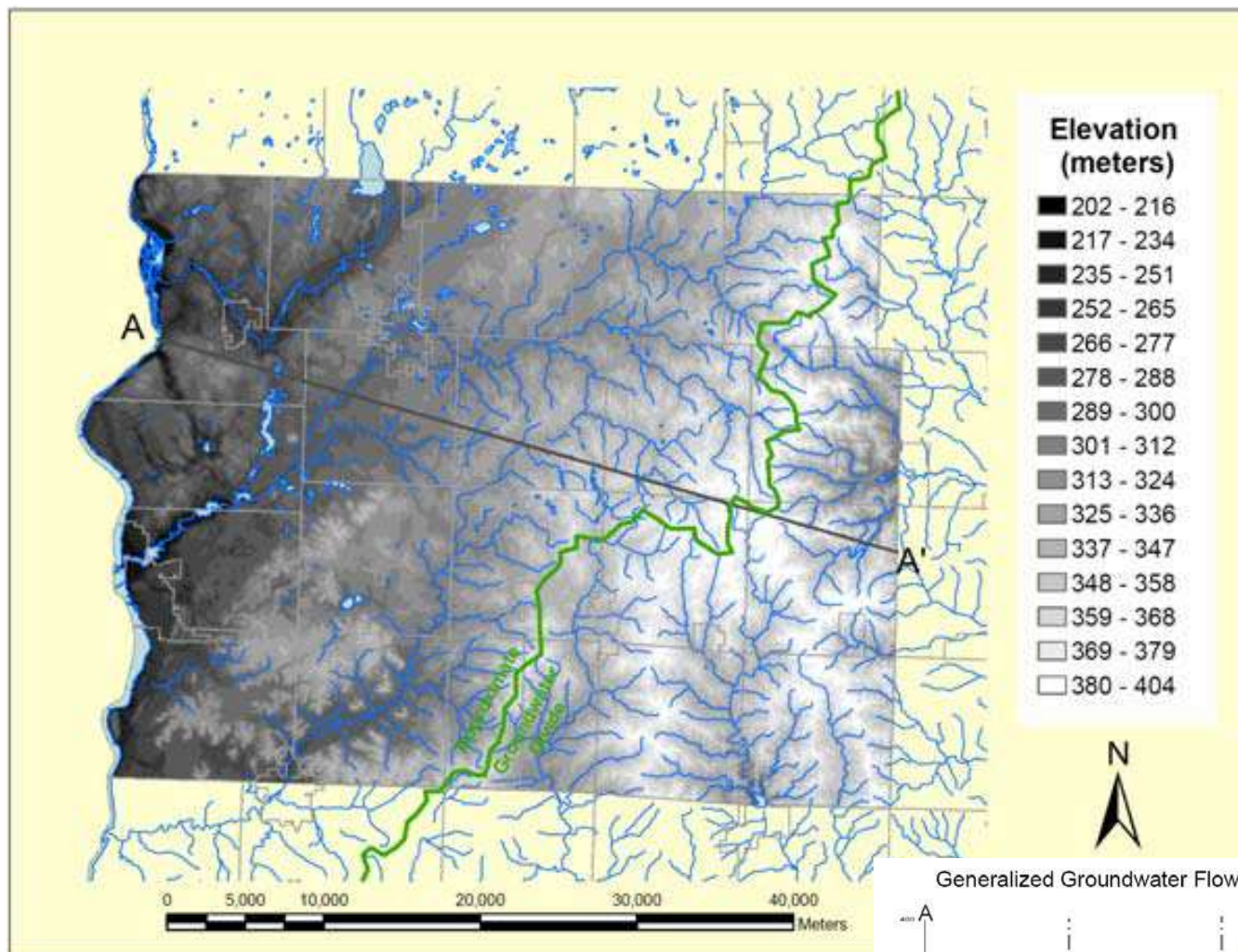


Figure 16. Simulated water-table elevation, particle flow paths from the water table, and groundwater/surface-water interaction in the regional groundwater flow model, layer 1.

<https://wgnhs.uwex.edu/pubs/000282/>

<https://pubs.usgs.gov/sir/2009/5056/pdf/sir2009-5056.pdf>





# Municipal Water Systems

## Protecting Wisconsin's Groundwater Through Comprehensive Planning

### St. Croix County

return to [Executive Summary](#) - [Full Report](#)

#### MUNICIPAL WATER SYSTEMS <sup>21</sup>

Municipal water system	Wellhead protection plan	Wellhead protection ordinance
Baldwin Waterworks	Yes	Yes
Glenwood City Waterworks	No	No
Hammond Waterworks	Yes	Yes
Hudson Waterworks	Yes	Yes
New Richmond Waterworks	No	No
North Hudson Waterworks	No	No
Roberts Waterworks	Yes	No
Somerset Waterworks	Yes	Yes
Star Prairie Waterworks	Yes	Yes
Wilson Waterworks	No	No
Woodville Waterworks	Yes	No

Of those municipal water systems that have wellhead protection (WHP) plans, some have a WHP plan for all of their wells, while others only have a plan for one or some of their wells. Similarly, of those municipal water systems that have WHP ordinances, some ordinances apply to all of their wells and others just one or some of their wells.

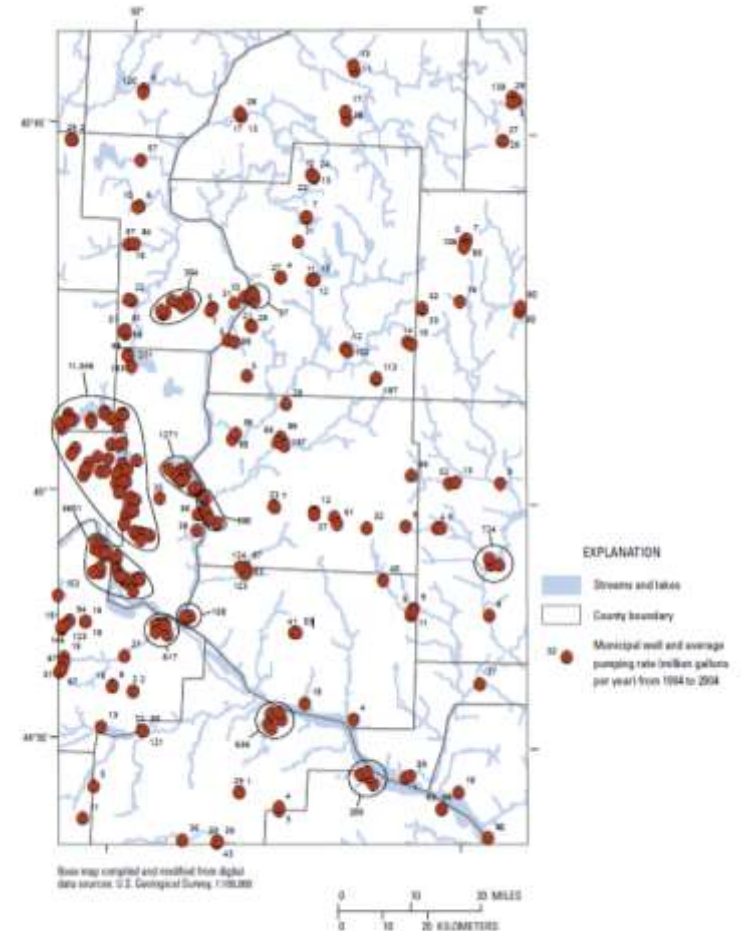
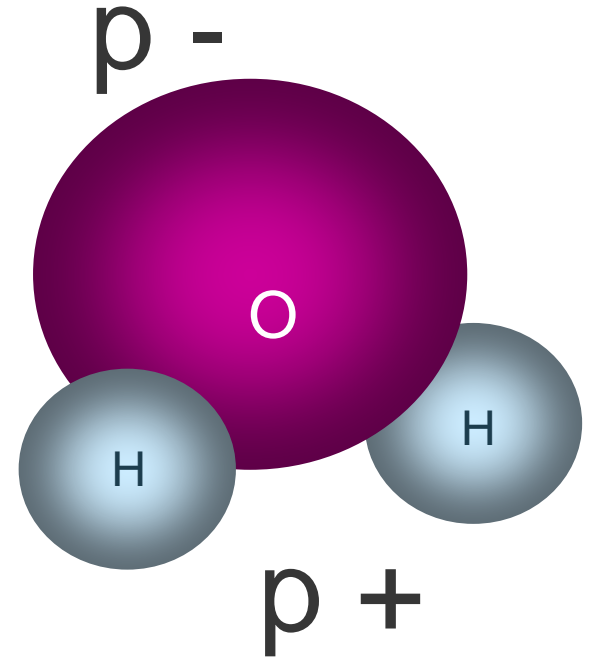


Figure 2A. Location of municipal wells in and near Pierce, Polk, and St. Croix Counties, Wisconsin.

<https://pubs.usgs.gov/sir/2009/5056/pdf/sir2009-5056.pdf>

# water basics

- “Universal Solvent”
- Naturally has “stuff” dissolved in it.
  - Impurities depend on rocks, minerals, land-use, plumbing, packaging, and other materials that water comes in contact with.
- Can also treat water to take “stuff” out

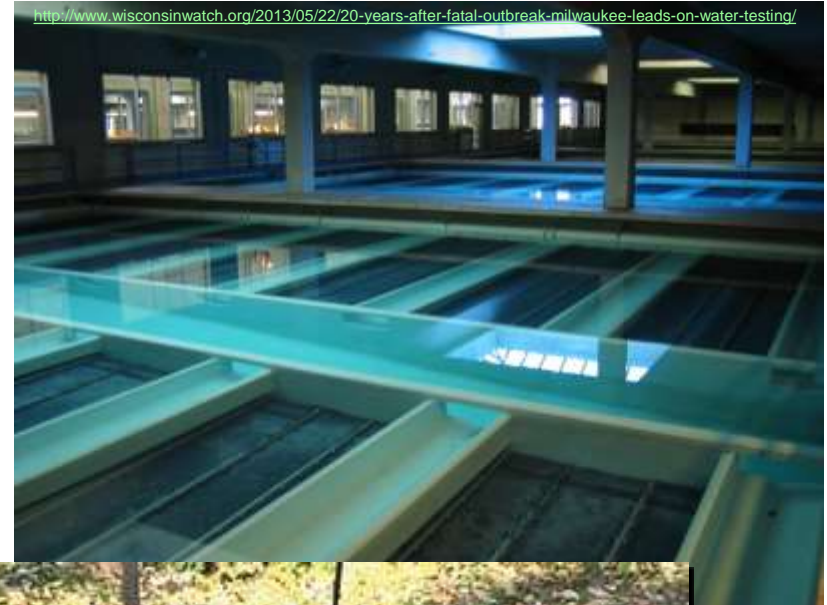




# Private vs. Public Water Supplies

## Public Water Supplies

- Regularly tested and regulated by drinking water standards.



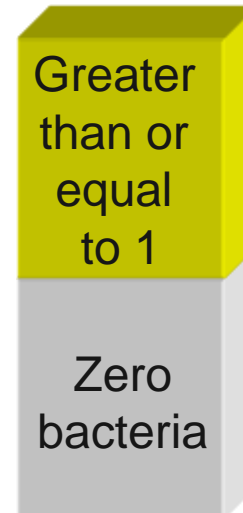
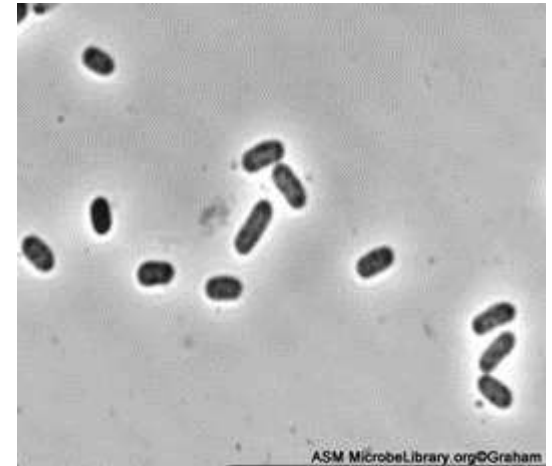
## Private Wells

- Not required to be regularly tested.
- Not required to take corrective action
- Owners must take special precautions to ensure safe drinking water.



# Coliform bacteria

- Generally do not cause illness, but indicate a pathway for potentially harmful microorganisms to enter your water supply.
  - Harmful bacteria and viruses can cause gastrointestinal disease, cholera, hepatitis
- Well Code: “Properly constructed well should be able to provide bacteria free water continuously without the need for treatment”
- Recommend using an alternative source of water until a test indicates your well is absent of coliform bacteria
- Sources:
  - Live in soils and on vegetation
  - Human and animal waste
  - Sampling error



Present = Unsafe

Absent = Safe

# If coliform bacteria was detected, we also checked for e.coli bacteria test

- Confirmation that bacteria originated from a human or animal fecal source.
- E. coli are often present with harmful bacteria, viruses and parasites that can cause serious gastrointestinal illnesses.
- Any detectable level of E.coli means your water is unsafe to drink.

Information Sources: United States Department of Health and Human Services – Centers for Disease Control and Prevention ([www.cdc.gov](http://www.cdc.gov)) and United States Environmental Protection Agency ([www.epa.gov](http://www.epa.gov))

Contaminants	Sources	Symptoms
<b>BACTERIA</b>		
<i>Escherichia coliform (E. coli)</i> <i>Salmonella</i> <i>Campylobacter</i> <i>E. coli</i> 0157 (Requires a special water test for detection. Causes similar, but more serious illness than other E.coli strains. Requires medical treatment.)	<ul style="list-style-type: none"> <li>• Infected human and animal feces</li> <li>• Manure</li> <li>• Septic systems</li> <li>• Sewage</li> </ul>	<ul style="list-style-type: none"> <li>• Gastrointestinal illness</li> <li>• Low-grade fever</li> <li>• Begins 12 hrs - 7 days after exposure</li> </ul>
<i>Leptosporidia</i>	<ul style="list-style-type: none"> <li>• Urine of livestock, dogs and wildlife</li> <li>• Manure</li> </ul>	<ul style="list-style-type: none"> <li>• High fever, severe headache and red eyes</li> <li>• Gastrointestinal illness</li> <li>• Begins 2-28 days after exposure</li> </ul>
<b>MICROSCOPIC PARASITES</b>		
<i>Cryptosporidia</i> <i>Giardia</i>	<ul style="list-style-type: none"> <li>• Infected human and animal feces</li> <li>• Manure</li> <li>• Septic systems</li> <li>• Sewage</li> </ul>	<ul style="list-style-type: none"> <li>• Gastrointestinal illness</li> <li>• Begins 2-14 days after exposure</li> </ul>
<b>VIRUSES</b>		
Norovirus	<ul style="list-style-type: none"> <li>• Infected human feces and vomit</li> <li>• Septic systems</li> <li>• Sewage</li> </ul>	<ul style="list-style-type: none"> <li>• Gastrointestinal illness</li> <li>• Low-grade fever &amp; headache</li> <li>• Begins 12-48 hrs after exposure</li> </ul>
<b>CHEMICALS</b>		
Nitrate	<ul style="list-style-type: none"> <li>• Fertilizers</li> <li>• Manure</li> <li>• Bio-solids</li> <li>• Septic systems</li> </ul>	Methemoglobinemia or "Blue Baby Syndrome" – No documented cases in Door County, but elevated nitrate levels in well water may indicate risk of contamination by additional pathogens.
Atrazine (trade-name herbicide for control of broadleaf and grassy weeds)	Estimated to be most heavily used herbicide in the U.S. in 1987/89, with its most extensive use for corn and soybeans in the Midwest, including WI. In 1993, it became a restricted-use herbicide nationally. U.S. EPA set a max. contaminant level (MCL) at 3 parts per billion for safe drinking water.	Short-term exposure above the MCL may cause: congestion of heart, lungs and kidneys; low blood pressure; muscle spasms; weight loss; damage to adrenal glands.  Long-term exposure above MCL may cause: weight loss, cardiovascular damage, retinal and some muscle degeneration; cancer.



# Some Common Pathways for Bacteria to Enter Your Water System



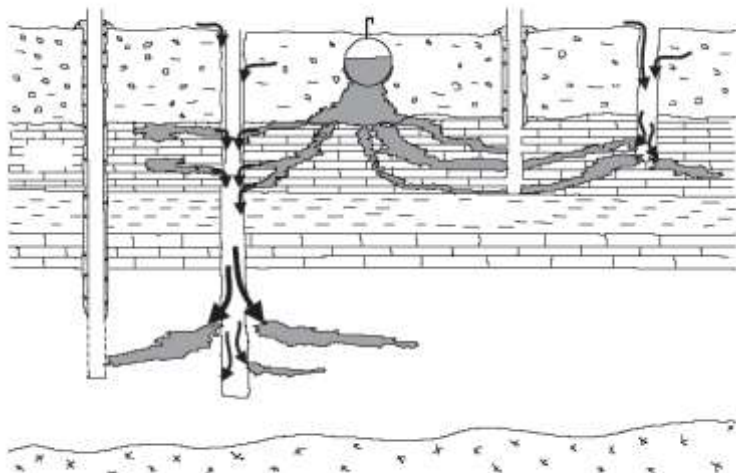
Photo: Sandy Heimke, WI DNR



Photo: Sandy Heimke, WI DNR



## AQUIFER CONTAMINATION THROUGH IMPROPERLY ABANDONED WELLS



Source: Adapted from DiNovo and Jaffe, 1994.

Codes R2, R3 and R4, Wisconsin Administrative Code prohibit the installation of a yard hydrant with a below-ground discharge. The code reads:

**"Stop and waste-type control valves may not be installed underground."**

This type of hydrant, with a below-ground discharge is popular because of the ease of operation and the relative low cost.



The plunger (control valve) is located below the first line. When the handle is lifted water enters the riser and flows through the head. A dike at the same level as the plunger allows water in the riser and the head to drain each time the handle is lowered. This draining action prevents freezing temperatures from causing the water in the hydrant riser or head to expand and burst the device. If a hose connected to the hydrant without a hose connection vacuum breaker was submerged in a barrel, the water contents of the barrel could be siphoned through the drain port and could contaminate the groundwater or even your drinking water supply.

If you have further questions, please check the Conference website at: <http://conferences.wisconsin.gov/SB-58-PlumbingProgram.html>

or, contact your local plumbing inspector or, contact one of the consultants listed



Consultant Name	Phone/Fax
1. Ted Joyce	608-235-8077 / 608-263-7474
2. Tom Brown	715-340-3367 / 608-283-7435
3. Don Orosco	715-344-2887 / 608-263-7452
4. Dave Hough	715-434-4004 / 608-263-7431
5. Ryan Buckel	608-463-5998 / 608-263-7448

WI DNR website:

## What does an approved yard hydrant look like?



There's no "one" answer for a code-compliant yard hydrant. Many manufacturers produce models that are code compliant. When you buy a hydrant, make sure that it has an approved hose connection vacuum breaker and does not include an under-ground dike.

And if you install a hose connection vacuum breaker on a yard hydrant make sure you lower it during the winter to prevent freezing conditions from bursting the hydrant.

If you find a model that you have questions about, contact the department or your local plumbing inspector.

# Well Construction



Photos courtesy of: Matt Zoschke



# Nitrate and Human Health

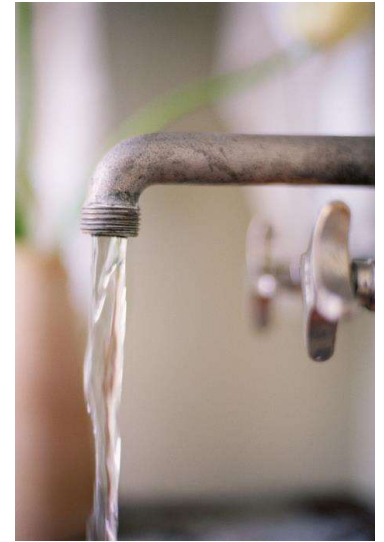
## Infants and pregnant women

- Methemoglobinemia or “blue-baby syndrome”
- Possible correlation to central nervous system malformations

## Adults

Possible correlations to:

- Non-Hodgkin’s lymphoma
- Various cancers (ex. gastric, bladder)
- Thyroid function
- Diabetes in children

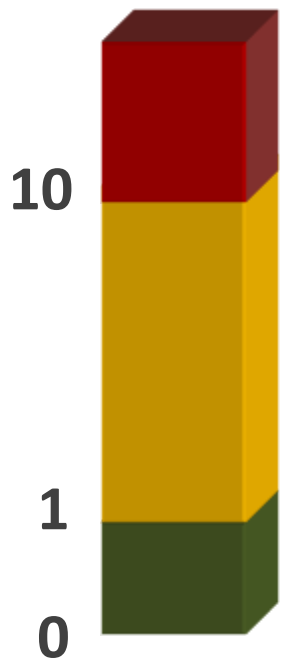


- \*Many are statistical studies that provide correlation between nitrate and health problems
- \*Studies don’t always agree, but cannot say with certainty that nitrate poses no health risk.

Nitrate often indicator of other possible contaminants  
(ex. other agricultural contaminants, septic effluent, etc.)

[Wisconsin Groundwater Coordinating Council, 2015](#); [Weyer, 1999](#)

# Nitrate in drinking water



- **Greater than 10 mg/L**  
*Impacted at a level that exceeds state and federal limits for drinking water*

- DO NOT give water to infants
- DO NOT consume if you are a woman who is pregnant or trying to conceive
- RECOMMEND everyone avoid long-term consumption

- **Between 1 and 10 mg/L**  
*Evidence of land-use impacts*

Considered suitable for drinking water

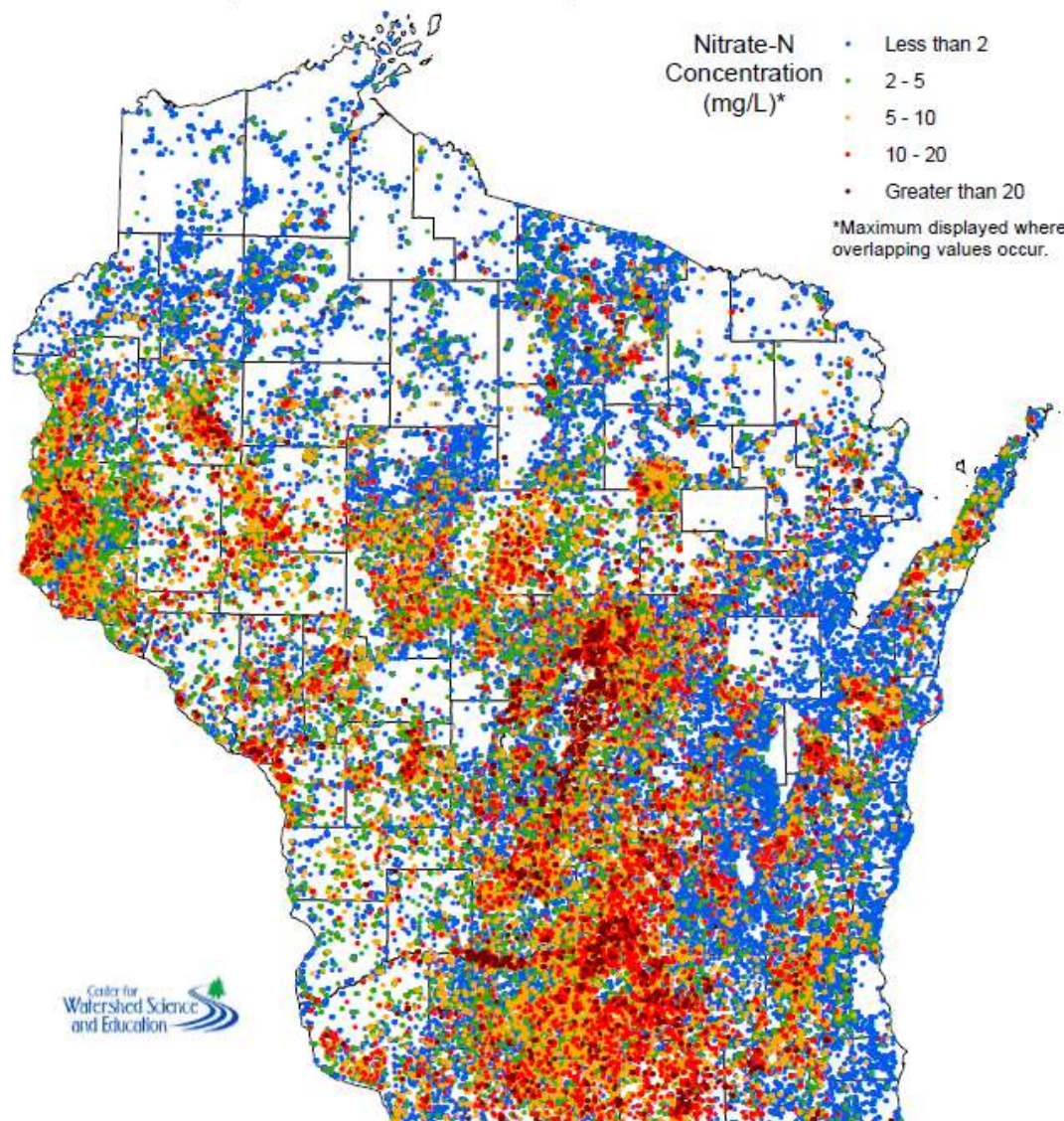
- **Less than 1 mg/L**  
*Natural or background levels in WI groundwater*



# Private Well Nitrate Concentrations

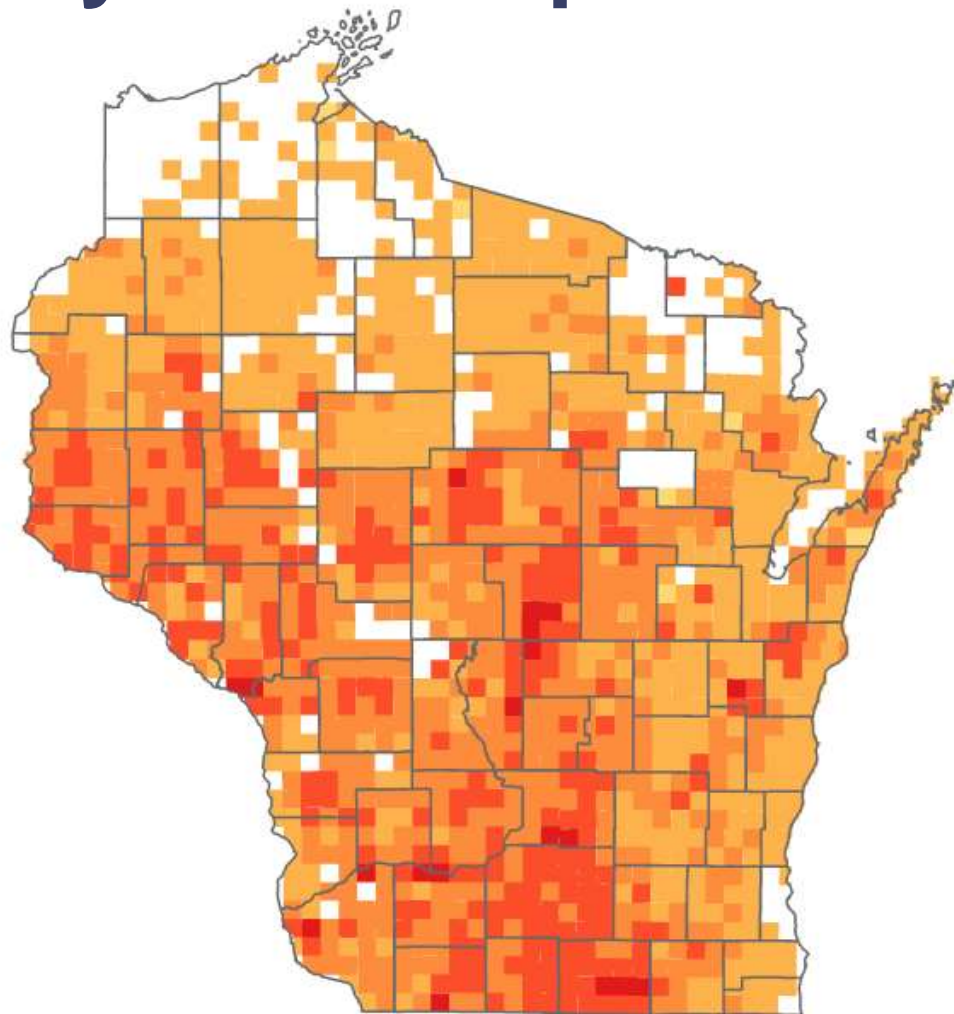
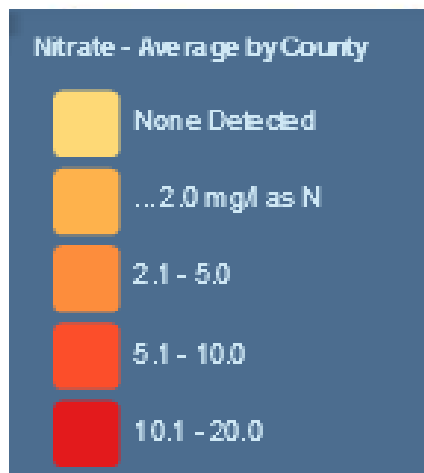


\*Maximum displayed where  
overlapping values occur.



Disclaimer: This map represents well water data in the Center for Watershed Science and Education database, WI DNR Groundwater Retrieval Network. It does not represent all known private wells.

# Average Nitrate-Nitrogen Concentration by Township



[WI Well Water Viewer, 2015](#)



# St. Croix County

1999 - 2005

## Nitrate-Nitrogen (mg/L)

- 0 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- > 20



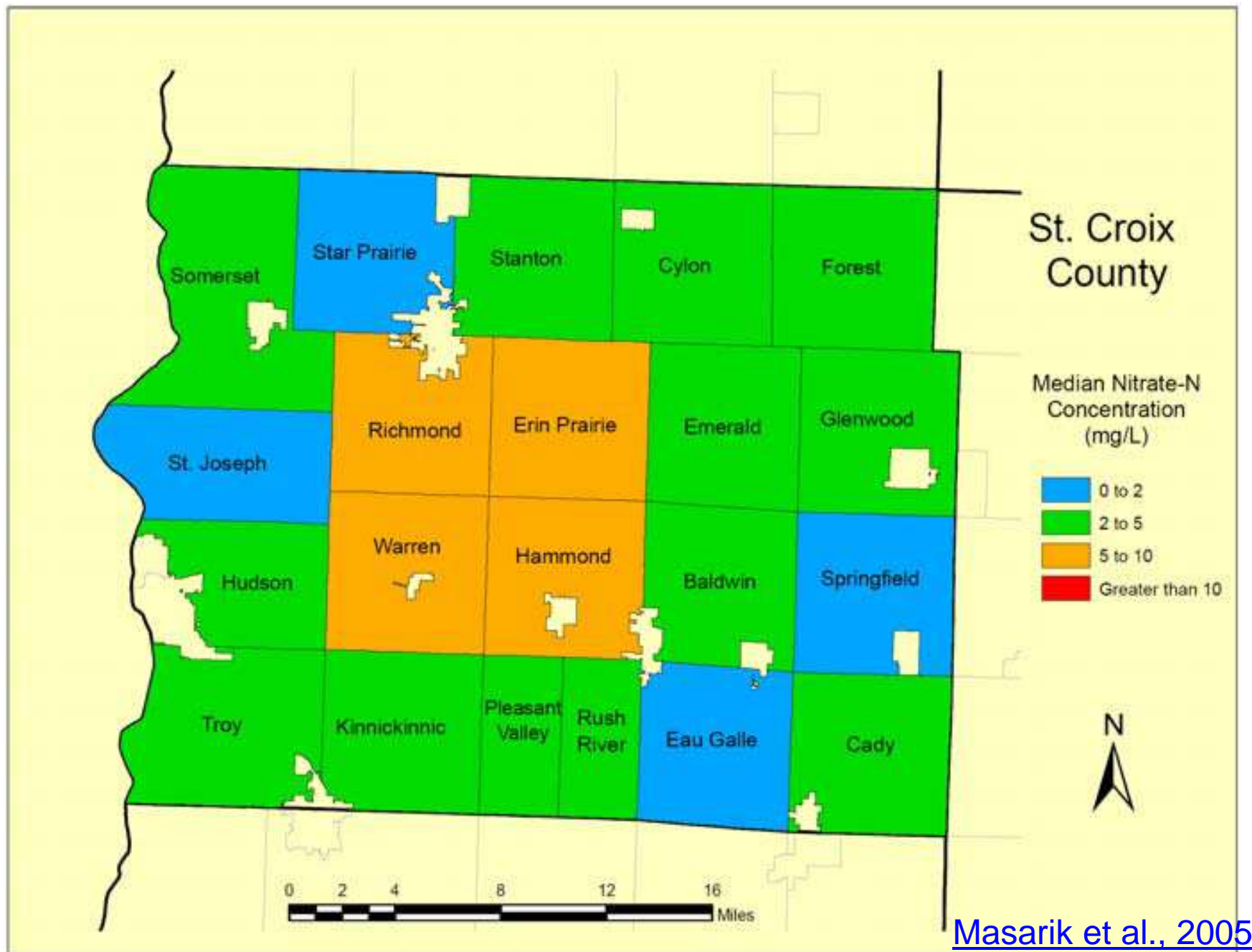
Center for  
Watershed Science  
and Education



0 2.5 5 10 15 20 Miles

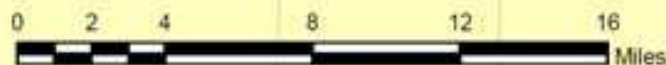
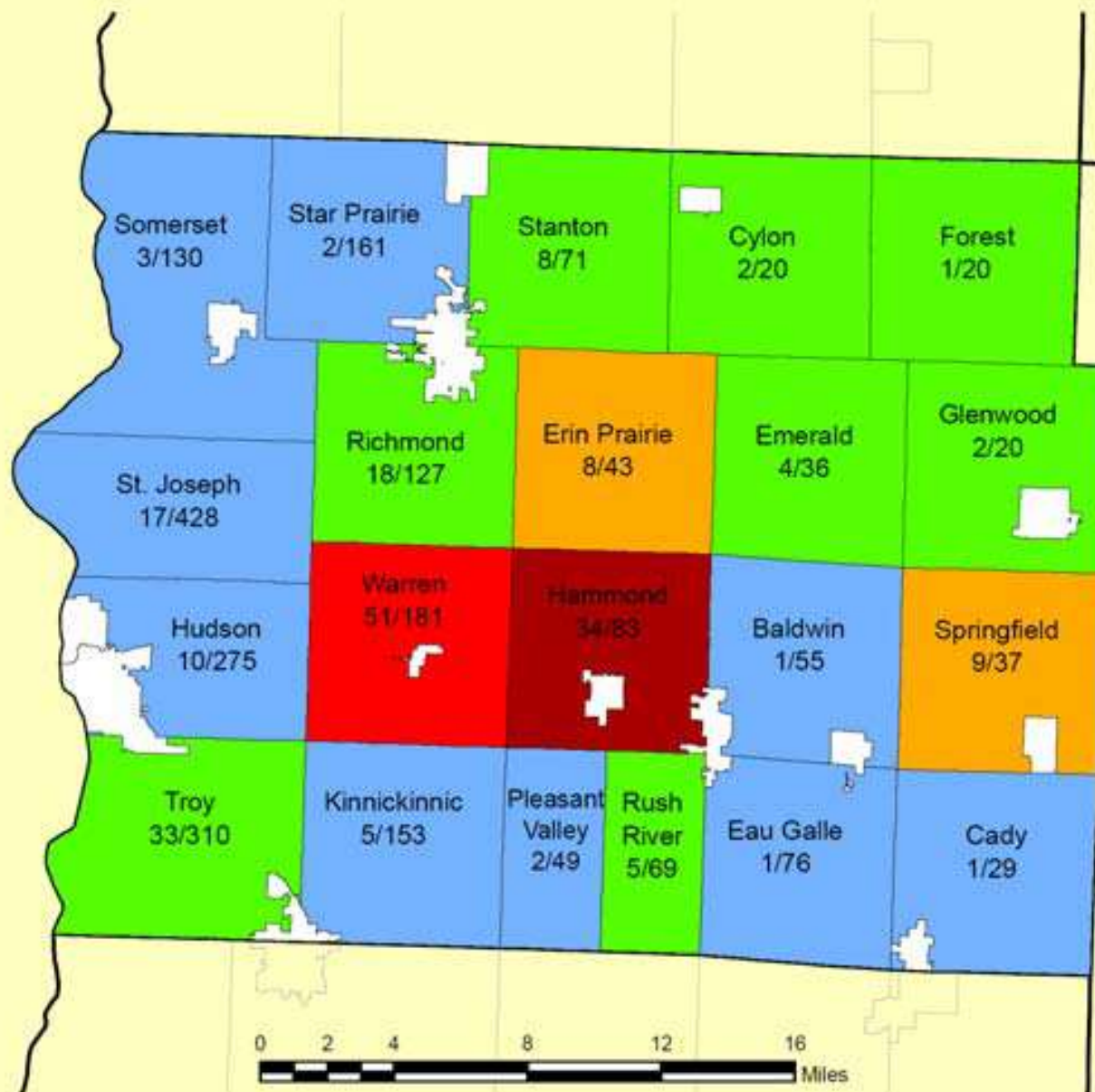
[Masarik et al., 2005](#)





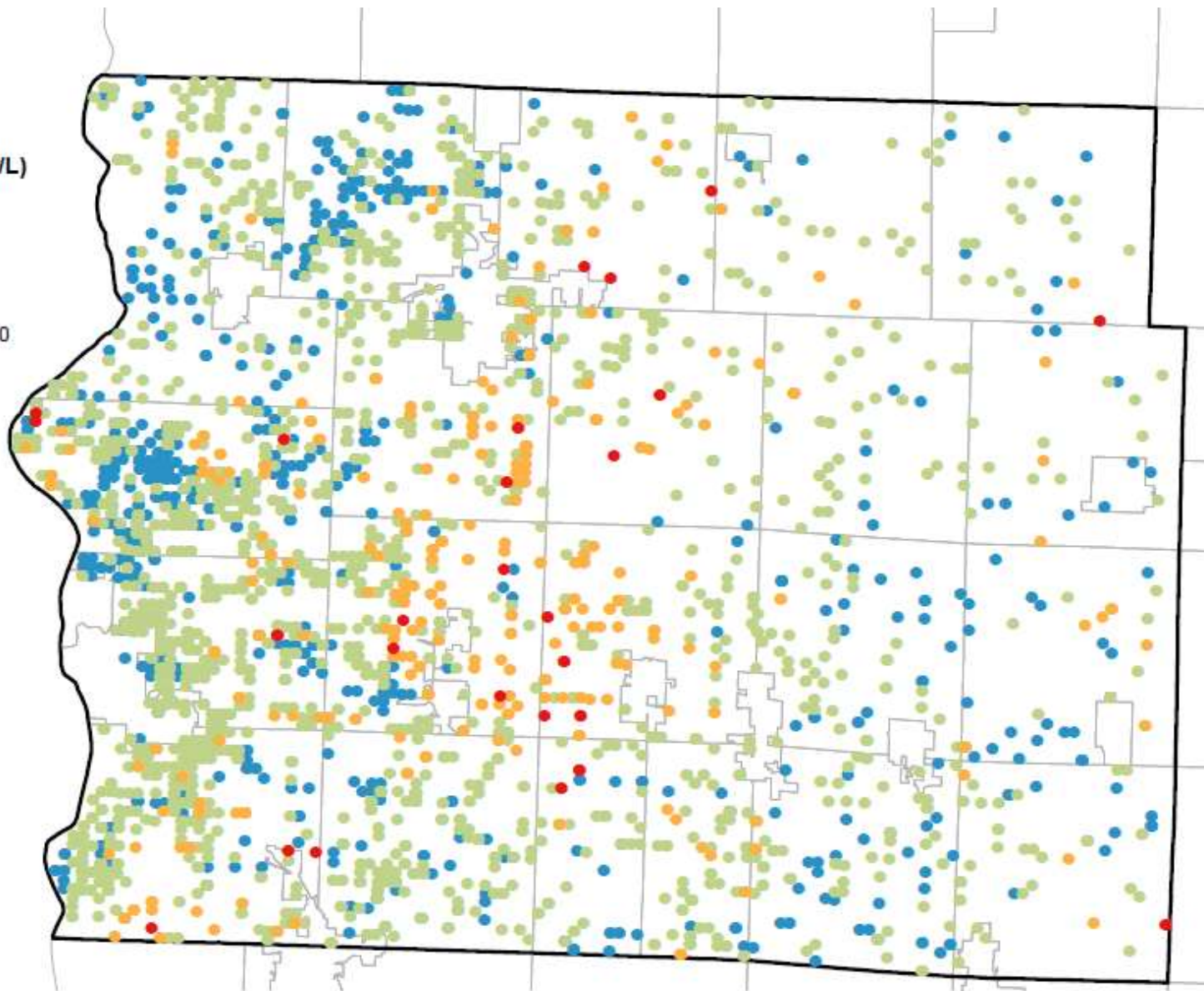
## St. Croix County

Percent of Samples  
that Exceed 10 mg/L  
Nitrate-N



**Nitrate-Nitrogen  
Concentration (mg/L)**

- Less than 2.0
- 2.0 to 10.0
- 10.1 - 20.0
- Greater than 20.0



Disclaimer: Contains data from water testing performed at the Water and Environmental Analysis Lab up through 2016.  
Does not represent all known wells.



# What can be done to reduce nitrate levels?

## ❑ Short term

### ❑ Municipal Wells ([GCC, 2015](#))

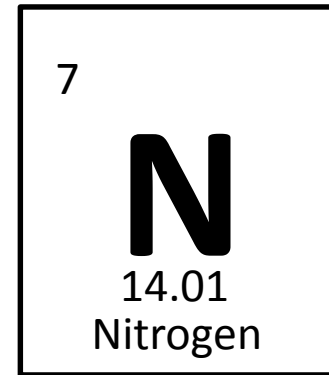
- ❑ 47 systems have spent >\$32 million as of 2012
  - ❑ Water Treatment
  - ❑ New wells
  - ❑ Blending

### ❑ Private Wells ([Lewandowski et. al. 2008](#))

- ❑ New well (not guaranteed, deeper adds to expense) - \$7,200
- ❑ Bottled water - \$190/person/year
- ❑ Water treatment devices \$800 + 100/yr
  - ❑ Reverse osmosis
  - ❑ Distillation
  - ❑ Anion exchange

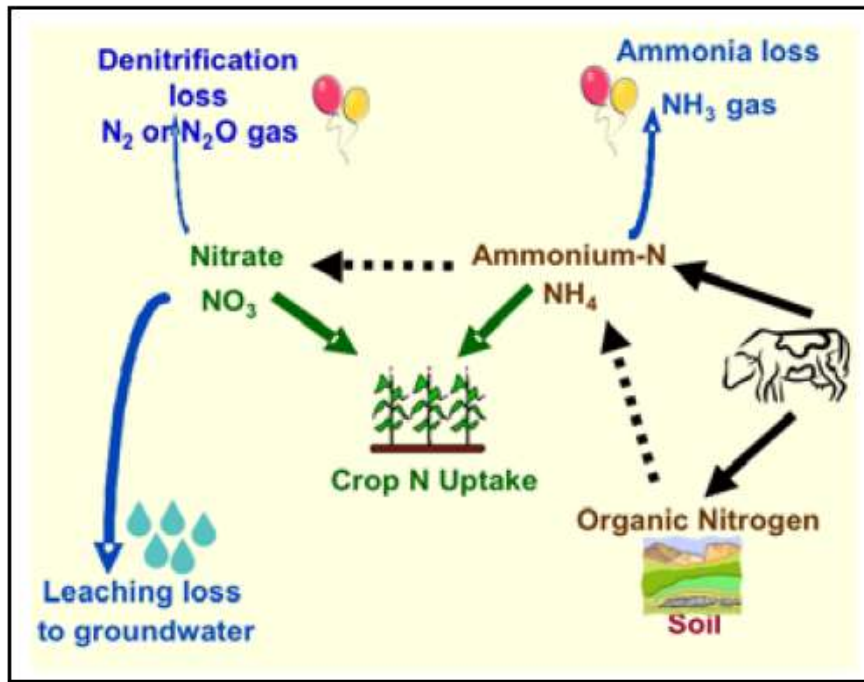
# Nitrogen is vital to agriculture

- Ancient civilizations farmed fertile flood plains
- Animal manures
- Crop rotations w/legumes
- Prairies and other organic rich soils
- Industrial fixation of N leads to commercial fertilizer and dramatic increase in N applications
- Manure management challenging



# Nitrogen Cycle

*“Nitrogen is neither created nor destroyed”*



<http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/20528/em8954-e.pdf>

## The Environment and N Loss from Manures—Why Do We Care?

Plant-available N (PAN) losses from the soil represent lost fertilizer value. Nitrogen can be lost as ammonia, nitrate, or nitrous oxides (Figure 1, page 3). Besides losing a valuable resource, the lost PAN can contribute to off-site problems.

Ammonia lost to the atmosphere is an air pollution problem in some areas of the western U.S., particularly in winter when atmospheric inversions prevent air mixing. In the atmosphere, ammonia can react with dust and other compounds to reduce visibility and to acidify rain or fog. Ammonia emissions may contribute to:

- Human health problems (inhalation hazard)
- Changes in natural plant communities in forests and rangeland. (Nitrogen deposited in N-poor ecosystems can alter the balance between adapted species and N-loving invasive species.)
- Acid fog or rain damage to limestone buildings or cultural artifacts (for example, petroglyphs on limestone)
- Reduction in visibility (haze)

Nitrate moves with soil water. Nitrate lost from soil enriches groundwater or surface water and can contribute to:

- Human health problems (blue baby syndrome, elevated cancer risk)
- Algae blooms in lakes or other slow-moving bodies of water
- Reduced survival and reproduction of some amphibians

Nitrous oxides lost to the atmosphere through denitrification can contribute to:

- Human health problems (inhalation hazard)
- Global warming (A molecule of nitrous oxide ( $N_2O$ ) traps approximately 300 times more heat than a molecule of carbon dioxide.)
- Increased N deposits in sensitive ecosystems, resulting in soil acidification or change in plant communities
- Reduction in visibility (haze)



# Nutrient Management and Nitrogen Recommendations

Nitrogen Fertilizer Added (lb/acre)

Low



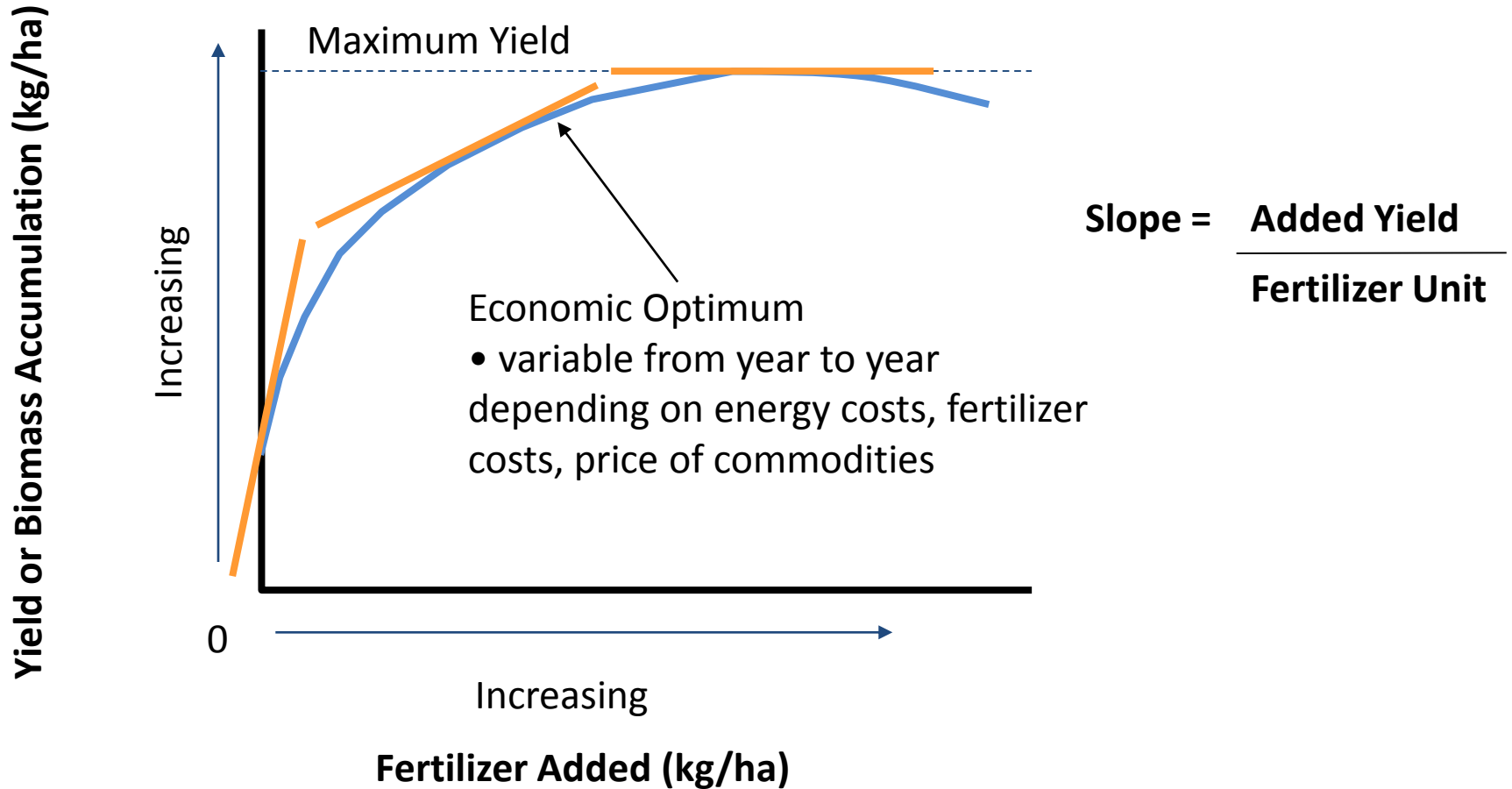
High



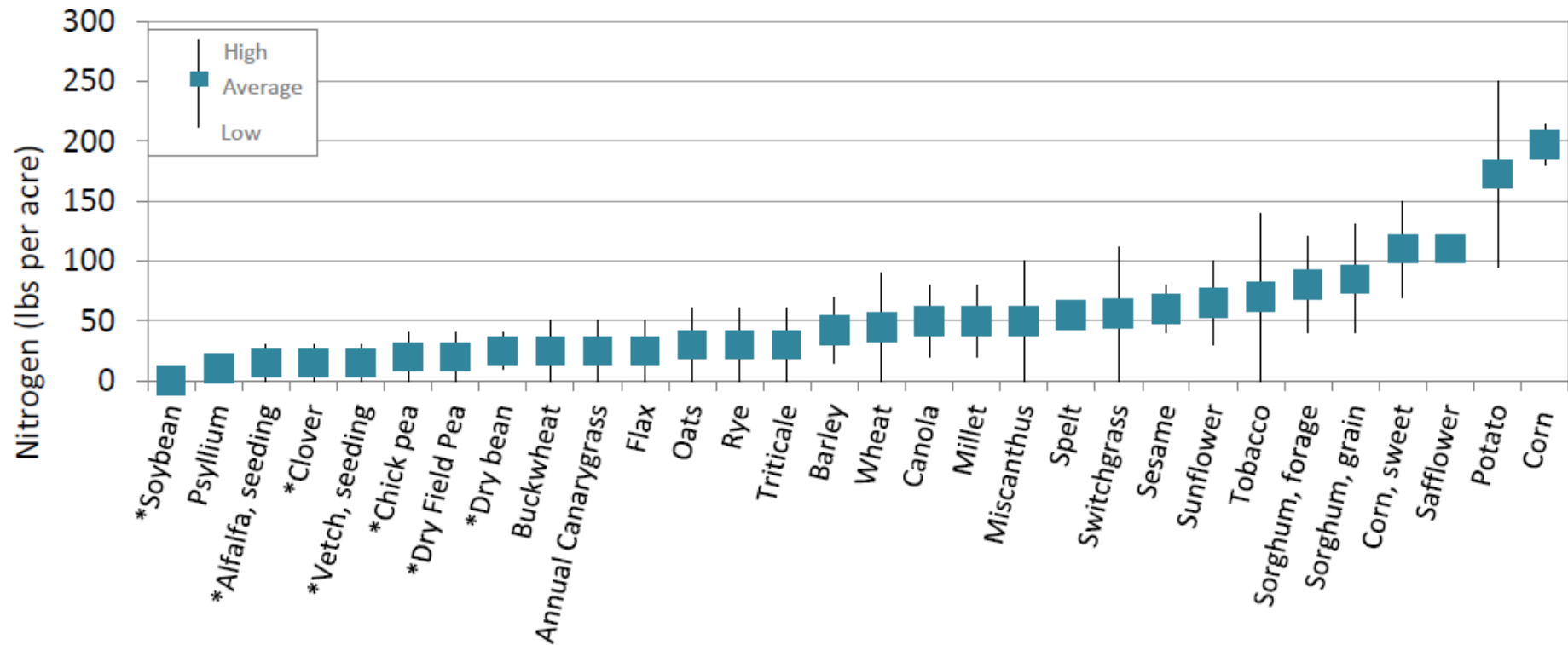
Picture Courtesy of:

<https://www.facebook.com/University-of-Minnesota-Nutrient-Management-Group-275963965756114/timeline/>

# Yield response to nitrogen



# Nitrogen fertilizer recommendations for common crops

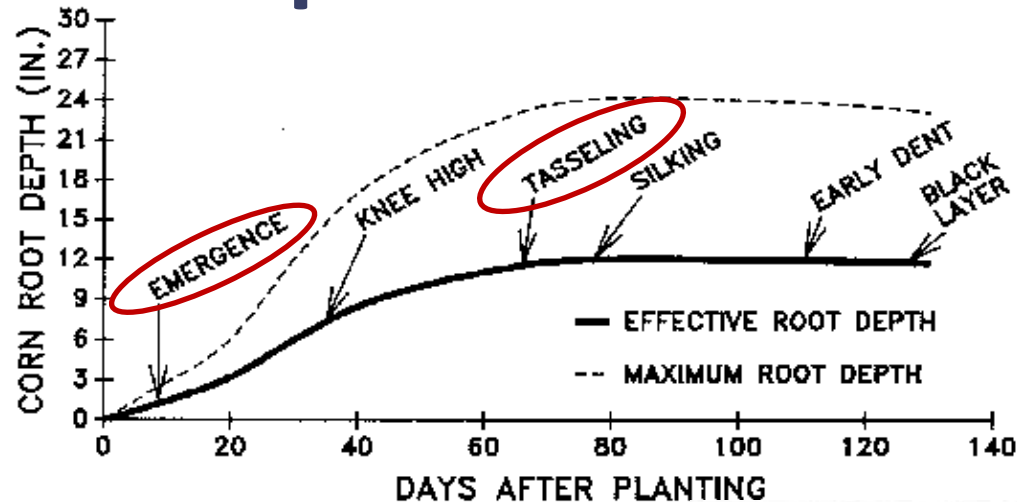


\* Legumes have symbiotic relationship with N fixing bacteria

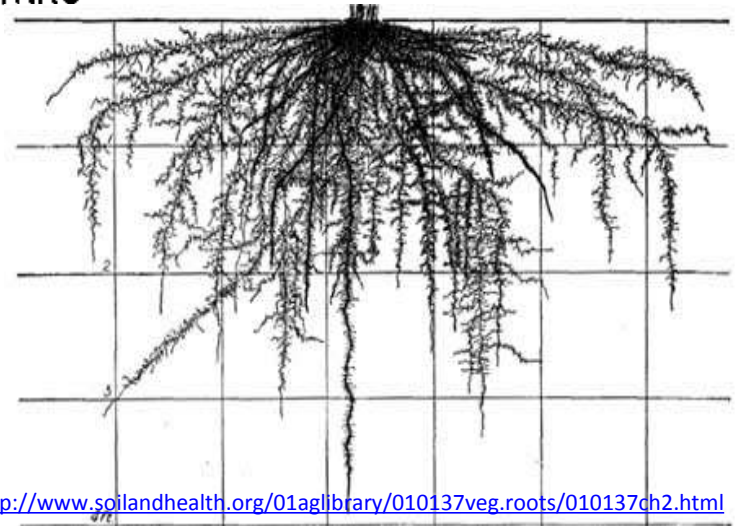
Alternative Field Crops Manual, 1989. University of Minnesota and University of Wisconsin -Madison  
[Nutrient application guidelines for field, vegetable and fruit crops in Wisconsin. A2809](#). 2012. University of Wisconsin-Madison  
 Miscanthus and switchgrass recommendations: Anderson et al., 2013; McIsaac et al., 2010; Vogel et al., 2002; Arundale et al, 2014



# Efficiency of plants at utilizing nitrogen – the corn example

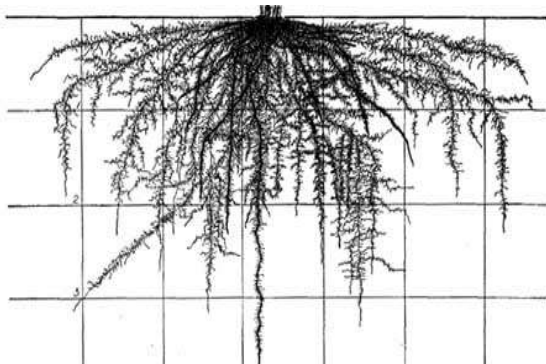


<http://www.bae.ncsu.edu/programs/extension/evans/ag452-1.html>



<http://www.soilandhealth.org/01aglibrary/010137veg.roots/010137ch2.html>

# Comparing Annual to Perennial Ecosystems

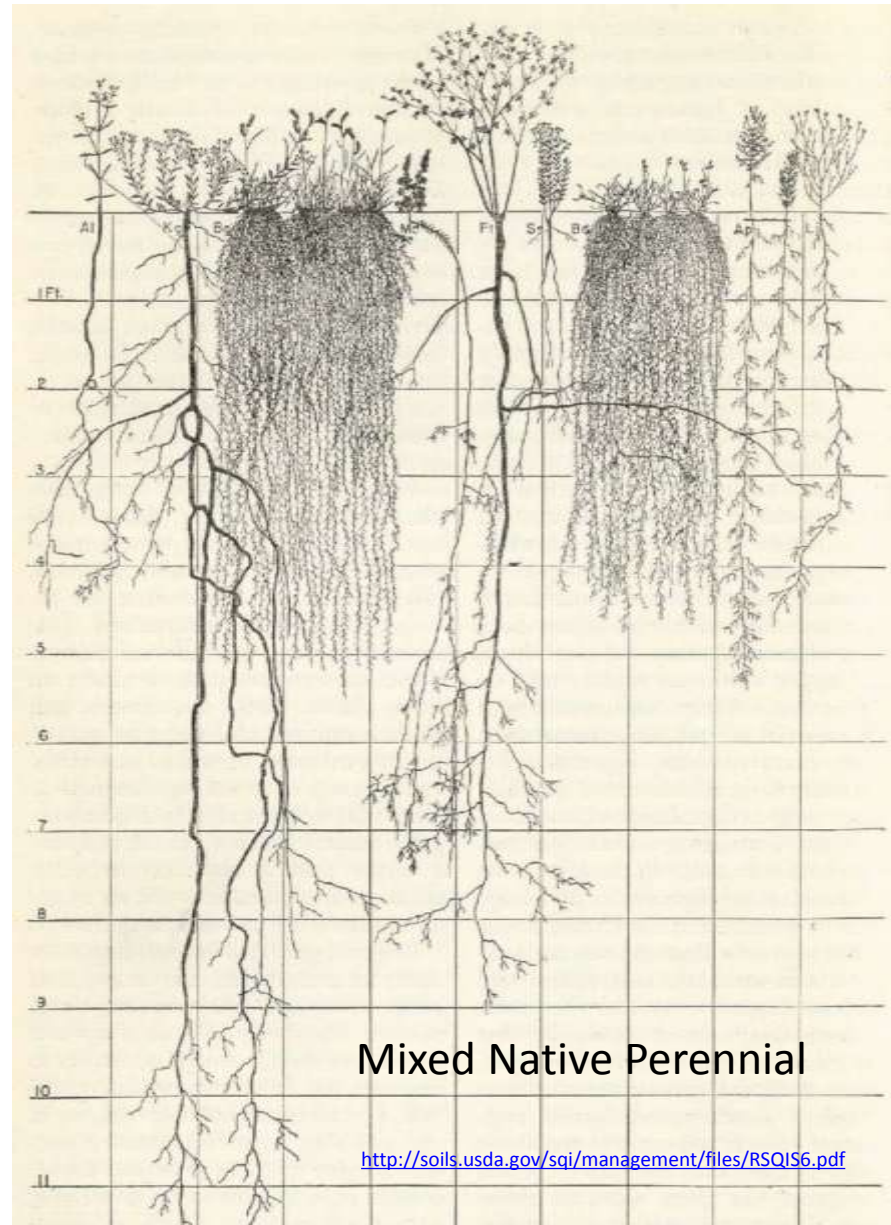


<http://www.soilandhealth.org/01aglibrary/010137veg.roots/010137ch2.html>

**Nitrogen fertilizer use  
efficiency for Midwestern  
corn systems**

**37%**

**([Cassman et. al. 2002](#))**



Mixed Native Perennial

<http://soils.usda.gov/sqi/management/files/RSQIS6.pdf>

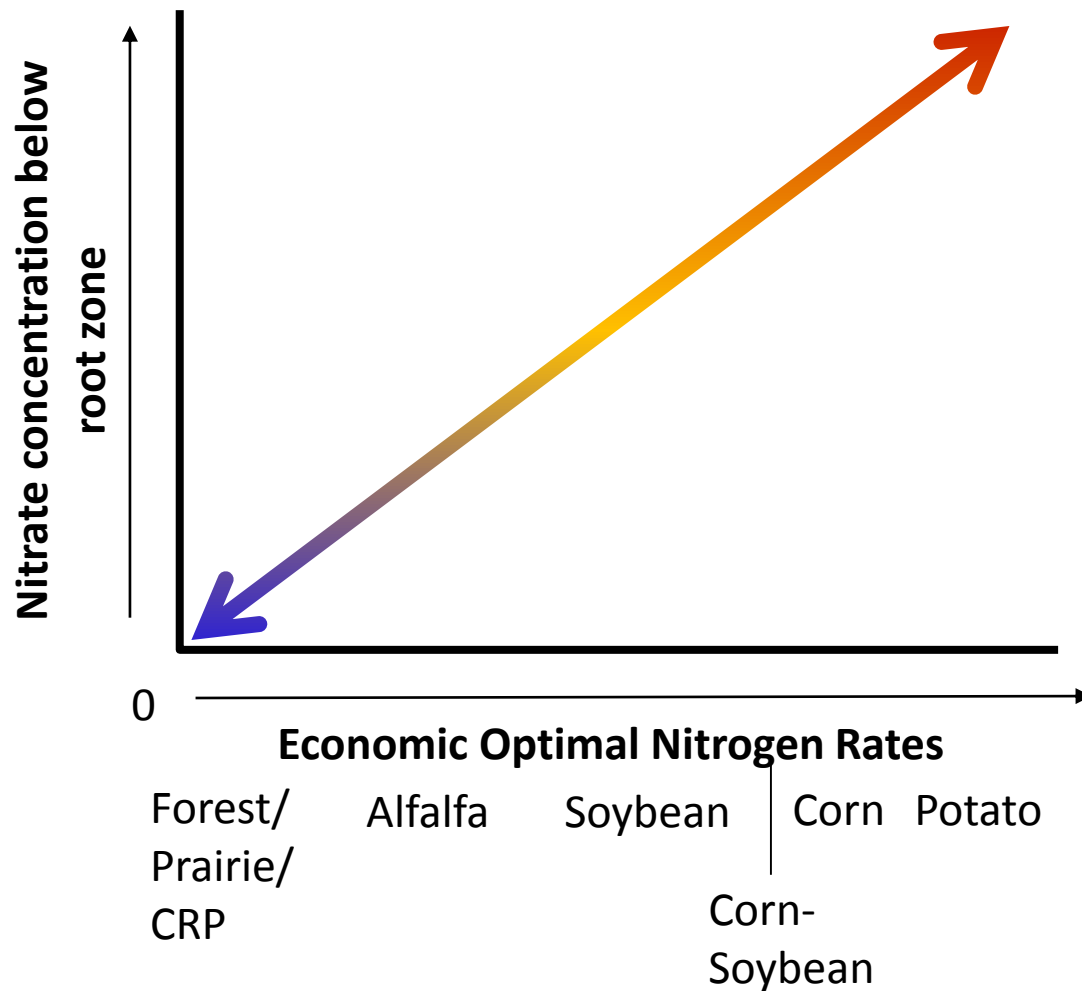
# Effect of cropping systems on nitrate leaching loss in the Midwest

	Cropping systems	N Inputs kg N ha <sup>-1</sup> yr <sup>-1</sup>	Nitrate-N Leaching kg N ha <sup>-1</sup> yr <sup>-1</sup>	Water Drainage mm yr <sup>-1</sup>	Data Source
Annual	Corn-Corn	138	55	193	<a href="#">Randall et al., 1997</a> (1)
		180	37	399	<a href="#">Masarik et al., 2014</a> (2)
		151-221	17-32	63-187	<a href="#">Thomas et al., 2014</a> (3)
		202	63	590	<a href="#">Weed and Kanwar, 1996</a> (4)
		202	43	280	<a href="#">Randall and Iragavarapu, 1995</a> (5)
	Corn-Soybean	136-0	51	226	<a href="#">Randall et al., 1997</a> (1)
		168-0	34-46	ND	<a href="#">Mclsaac et al., 2010</a> (6)
		168-0	34	470	<a href="#">Weed and Kanwar, 1996</a> (4)
		171-0	10-35	ND	<a href="#">Cambardella et al., 2015</a> (7)
Mixed	C-S-O/A-A	171-0-57-0	8-18	ND	<a href="#">Cambardella et al., 2015</a> (7)
Perennial	Alfalfa	0	2	104	<a href="#">Randall et al., 1997</a> (1)
	CRP	0	1	160	<a href="#">Randall et al., 1997</a> (1)
	Switchgrass	0	<1-4	ND	<a href="#">Mclsaac et al., 2010</a> (6)
		112	2-11	52-156	<a href="#">Thomas et al., 2014</a> (3)
	Miscanthus	0	2-7	ND	<a href="#">Mclsaac et al., 2010</a> (6)
		112	<1-1	52-147	<a href="#">Thomas et al., 2014</a> (3)
	Prairie	0	<1	122	<a href="#">Masarik, et al., 2014</a> (2)
	Pasture	0	1-10	ND	<a href="#">Cambardella et al., 2015</a> (7)

*\*16 -37X greater nitrate loss below continual corn cropping systems compared to perennial systems*

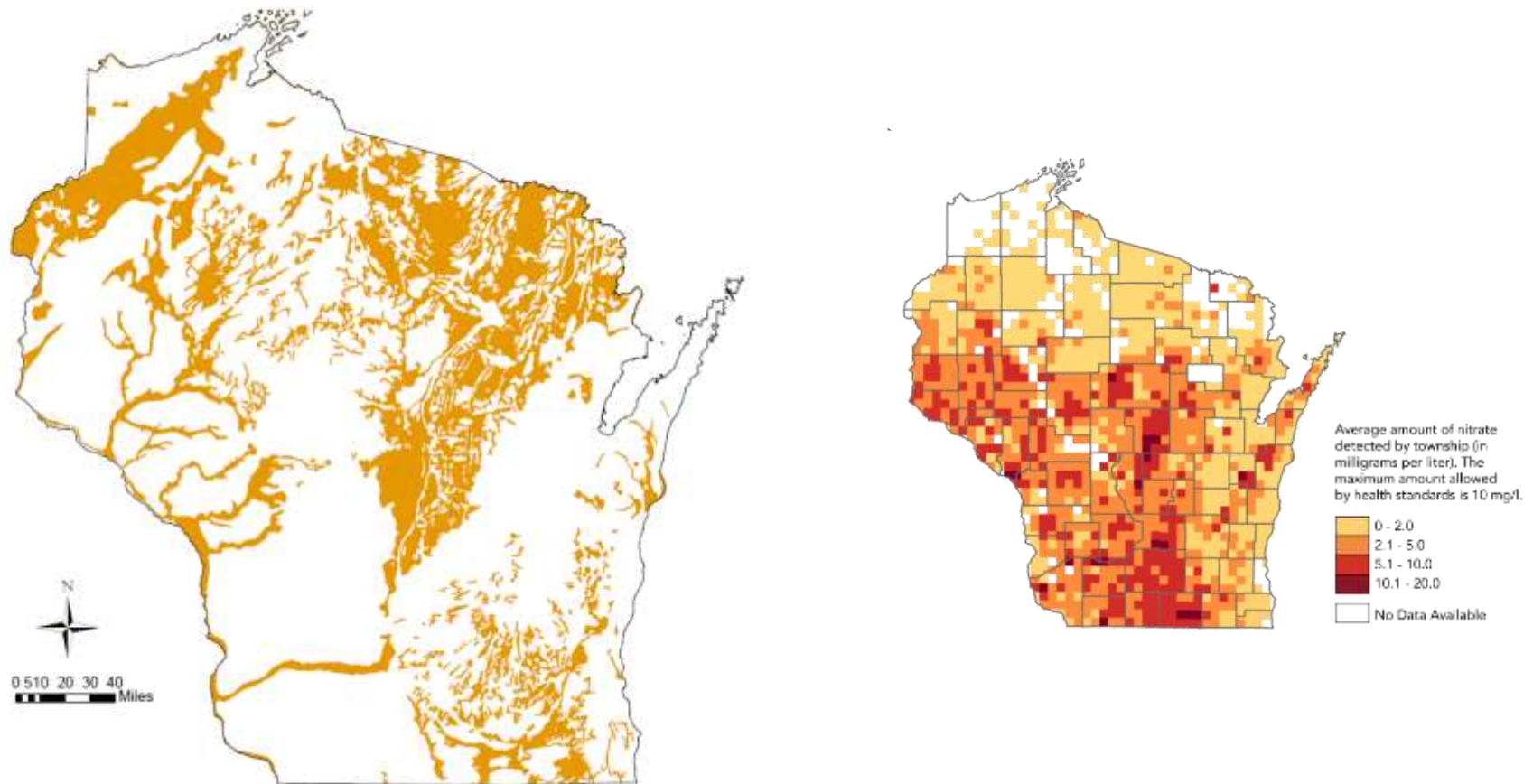


# Nitrate Leaching Potential



Masarik, UW-Extension

# Coarse textured surficial deposits



Map created using: Groundwater Contamination Susceptibility Model (GCSM); Surficial Deposits ("sdppw95c")

The GCSM was developed by the DNR, the US Geological Survey (USGS), the Wisconsin Geological & Natural History Survey (WGNHS), and the University of Wisconsin – Madison in the mid-1980s.

# Shallow carbonate rock aquifers

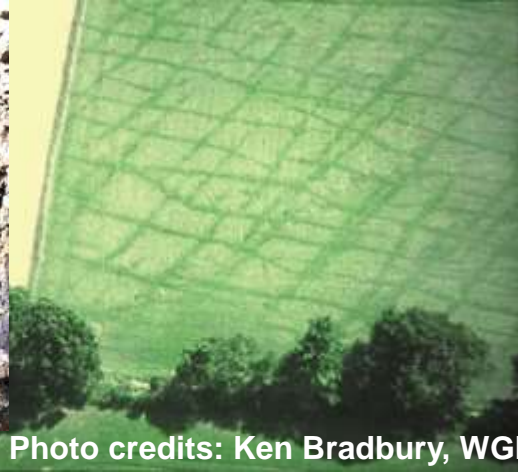
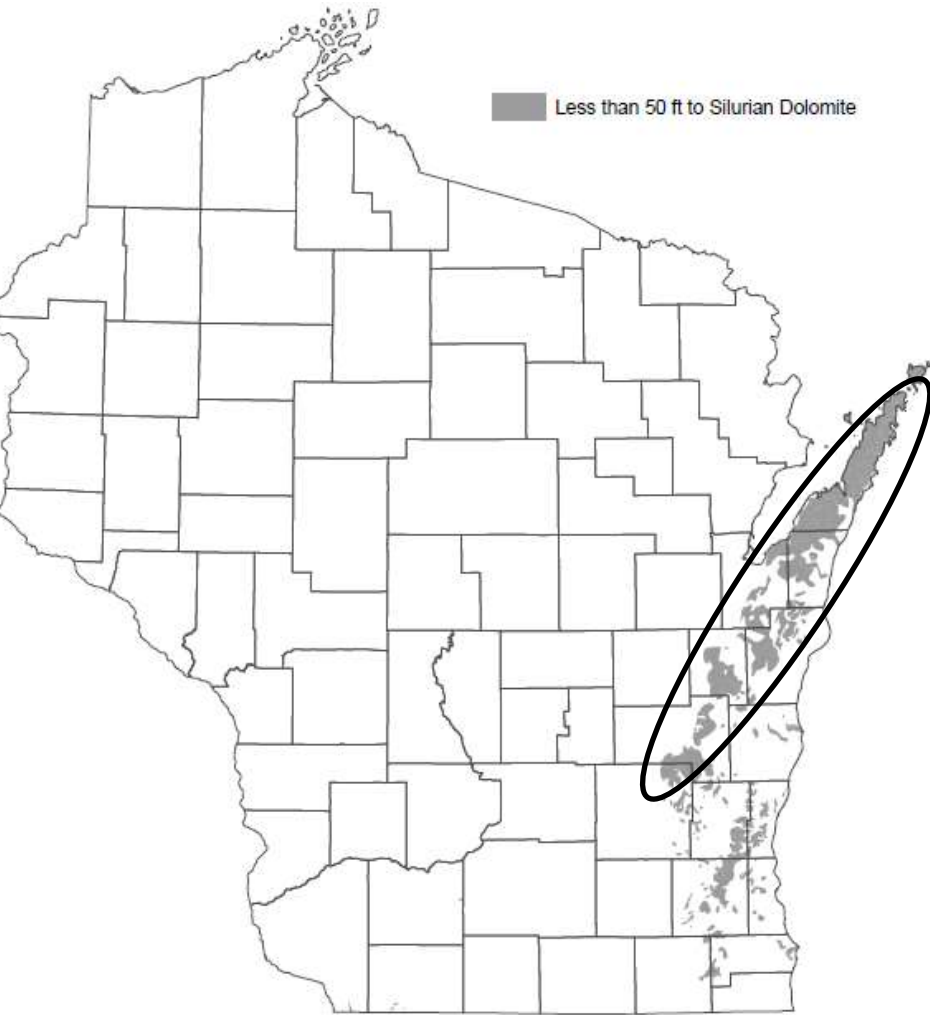
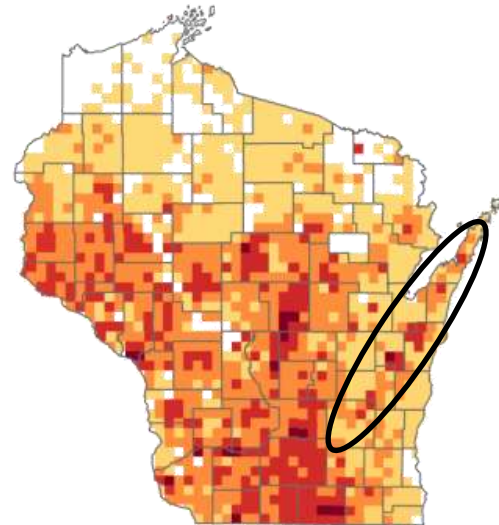
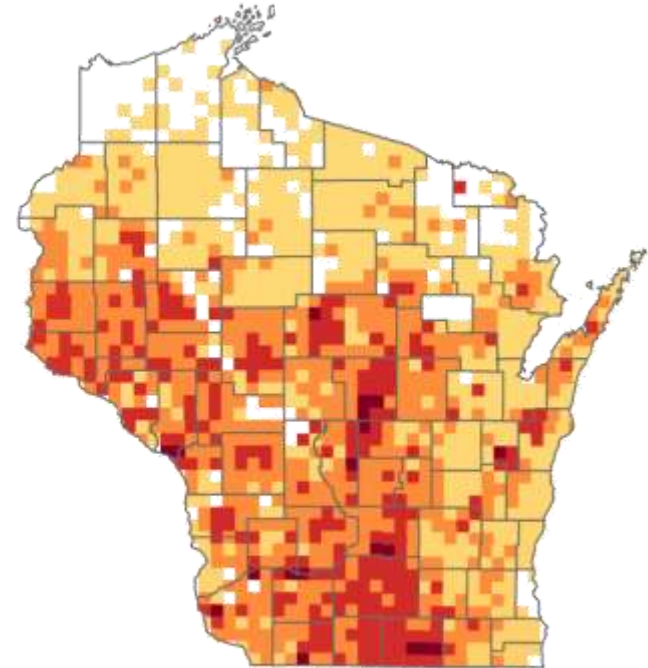
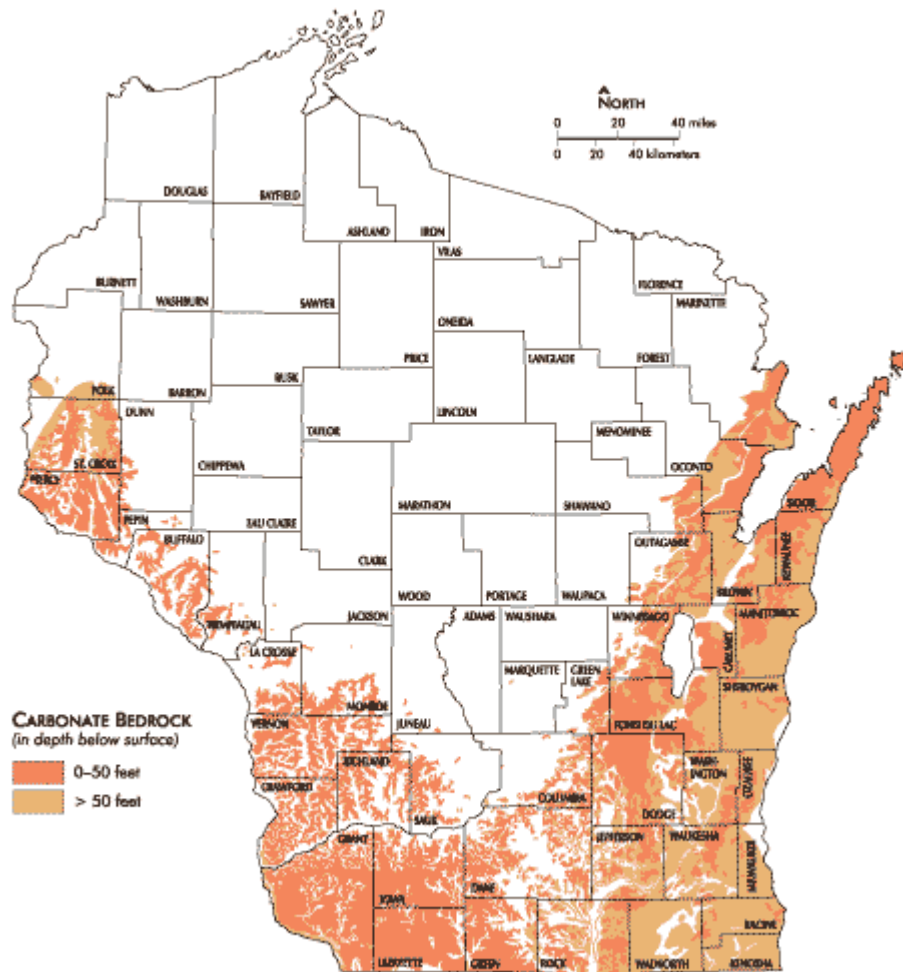


Photo credits: Ken Bradbury, WGI



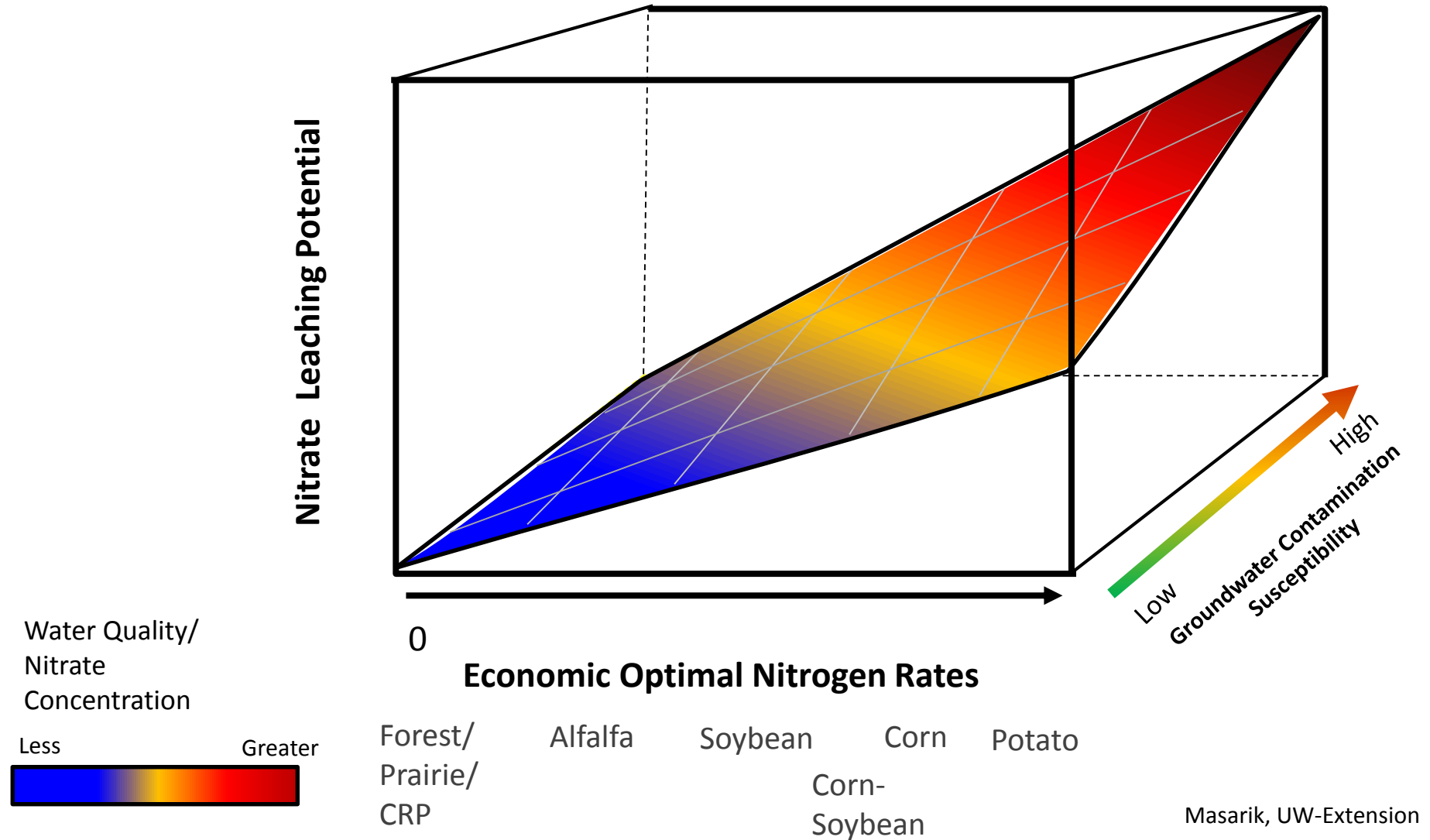


# Other areas of karst potential

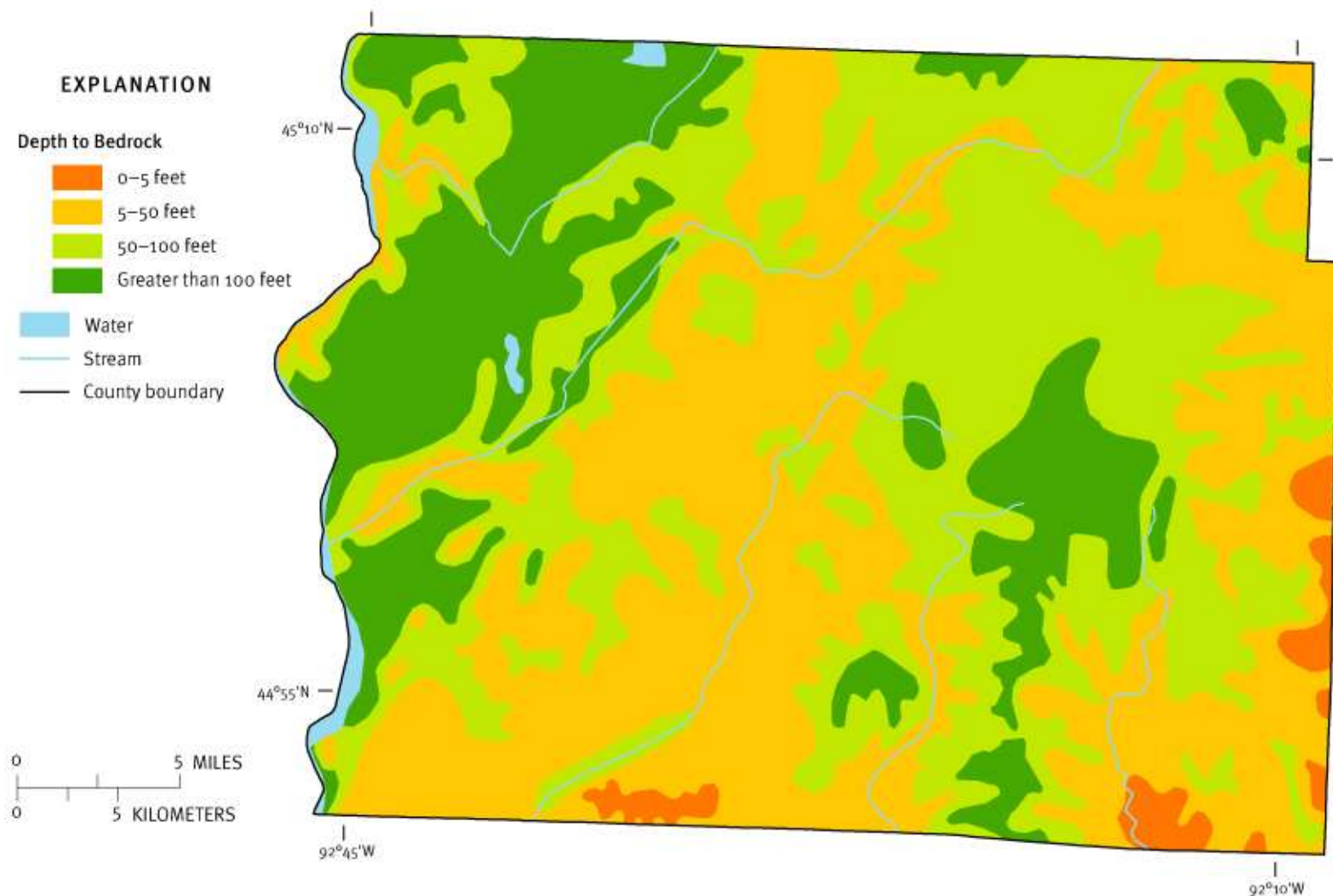


<https://wgnhs.uwex.edu/water-environment/karst-sinkholes/>

# Nitrate Leaching Potential



## St. Croix County – Depth to Bedrock




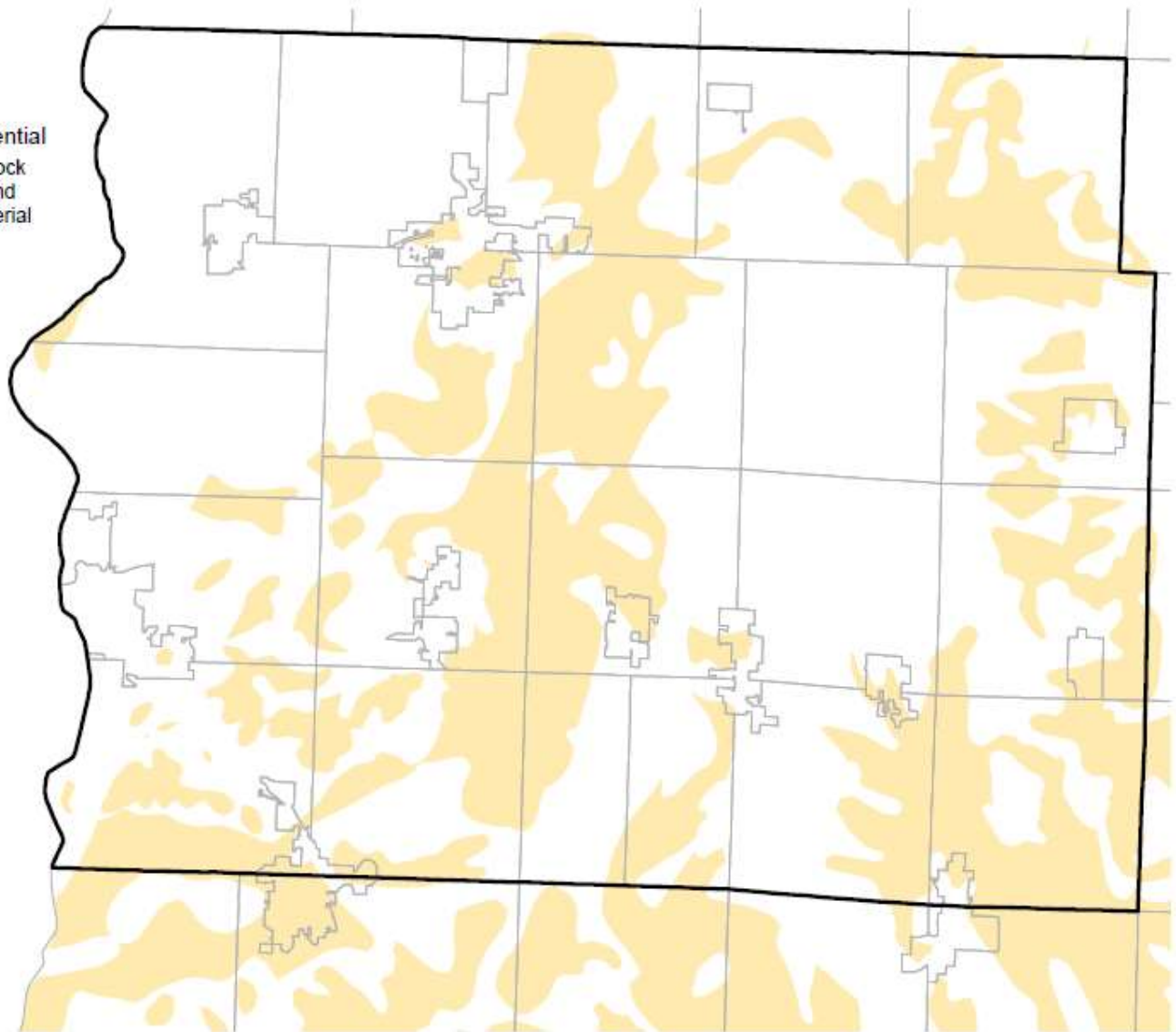
This resource characteristic map was derived from generalized statewide information at small scales, and cannot be used for any site-specific purposes.

Map source: Schmidt, R.R., 1987, Groundwater contamination susceptibility map and evaluation: Wisconsin Department of Natural Resources, Wisconsin's Groundwater Management Plan Report 5, PUBL-WR-177-87, 27 p.

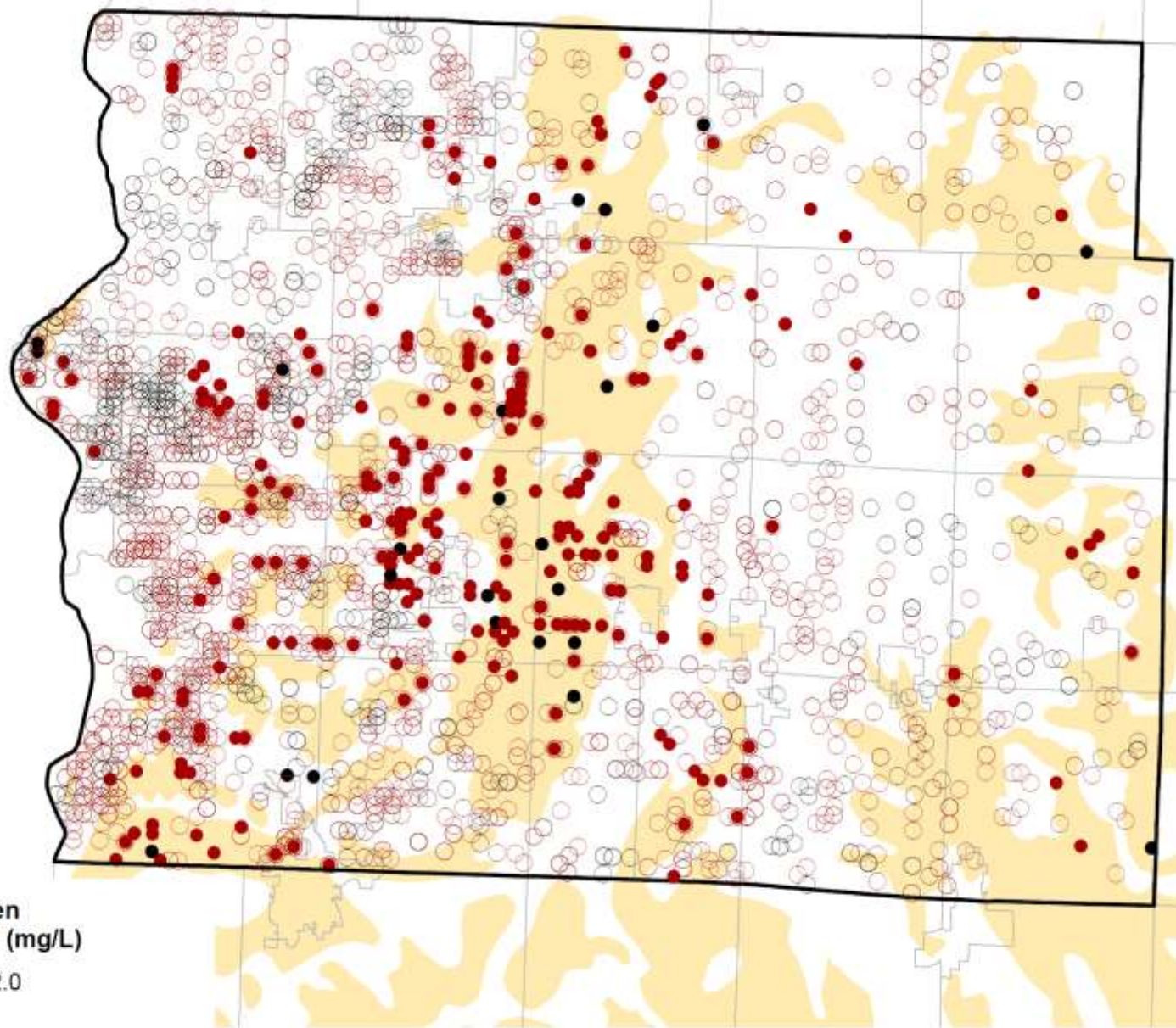
Figure created for the "Protecting Wisconsin's Groundwater Through Comprehensive Planning" web site, 2007, <http://wi.water.usgs.gov/gwcomp/>



 Moderate Karst Potential  
Areas where carbonate bedrock is uppermost bedrock unit and depth of unconsolidated material is between 0 and 50 ft.



Disclaimer: Karst potential determine using statewide depth to bedrock and bedrock geology map layers. Used here to illustrate the relationship between well water quality and dominant geologic controls. Scale is not appropriate for site specific planning. For more information about the depth to bedrock layer used to select sections, refer to the DNR publication, Wisconsin's Groundwater Management Plan: Report No. 5: Groundwater Contamination Susceptibility in Wisconsin, available from the DNR Bureau of Drinking Water & Groundwater.



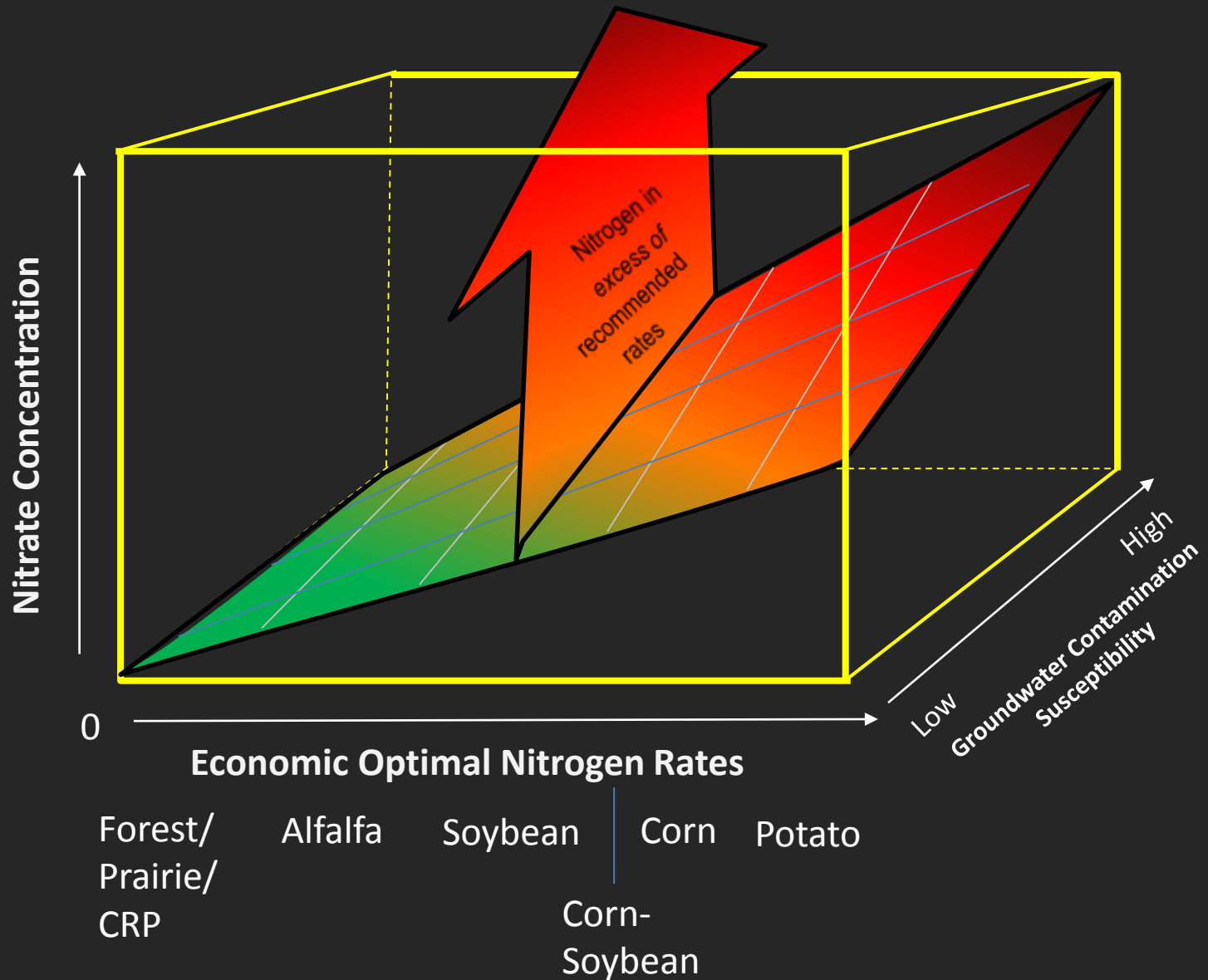
**Nitrate-Nitrogen  
Concentration (mg/L)**

- Less than 2.0
- 2.0 - 10.0
- 10.1 - 20.0
- Greater than 20.0

Moderate Karst Potential

Disclaimer: Karst potential determine using statewide depth to bedrock and bedrock geology map layers. Used here to illustrate the relationship between well water quality and dominant geologic controls. Scale is not appropriate for site specific planning. For more information about the depth to bedrock layer used to select sections, refer to the DNR publication, Wisconsin's Groundwater Management Plan: Report No. 5: Groundwater Contamination Susceptibility in Wisconsin, available from the DNR Bureau of Drinking Water & Groundwater.

# Nitrogen in excess of economic optimal rates

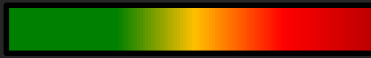




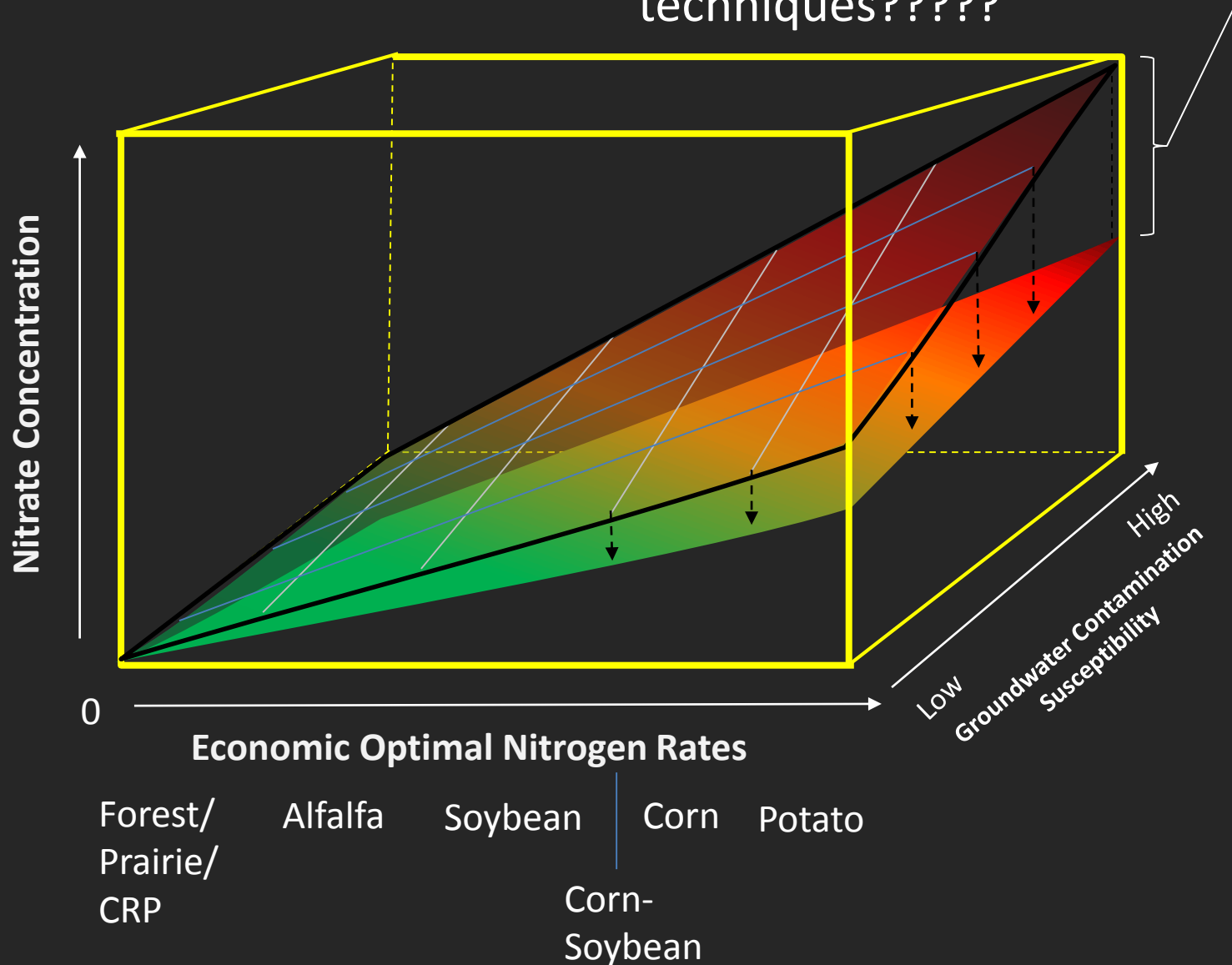
Water Quality/  
Nitrate  
Concentration

Good

Poor



# Improved Nitrogen Use Efficiency through *right form, right time and right place* techniques?????



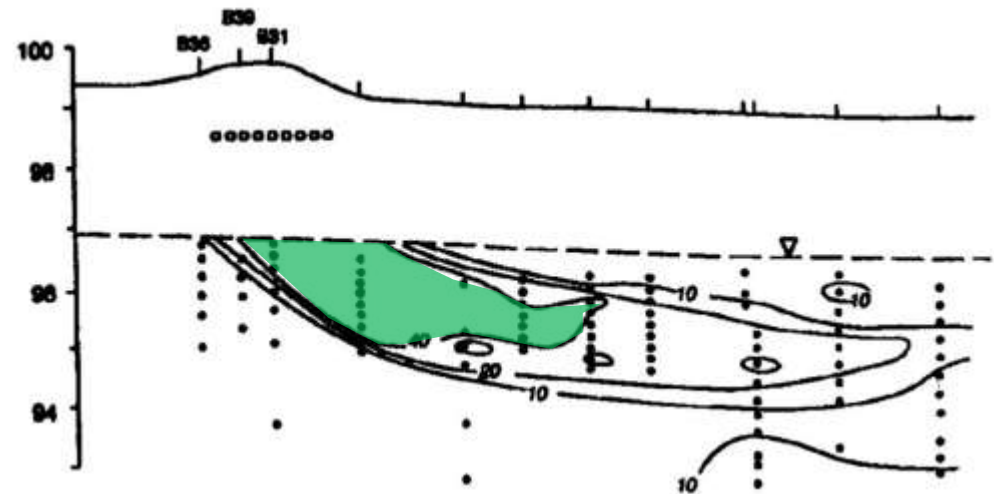
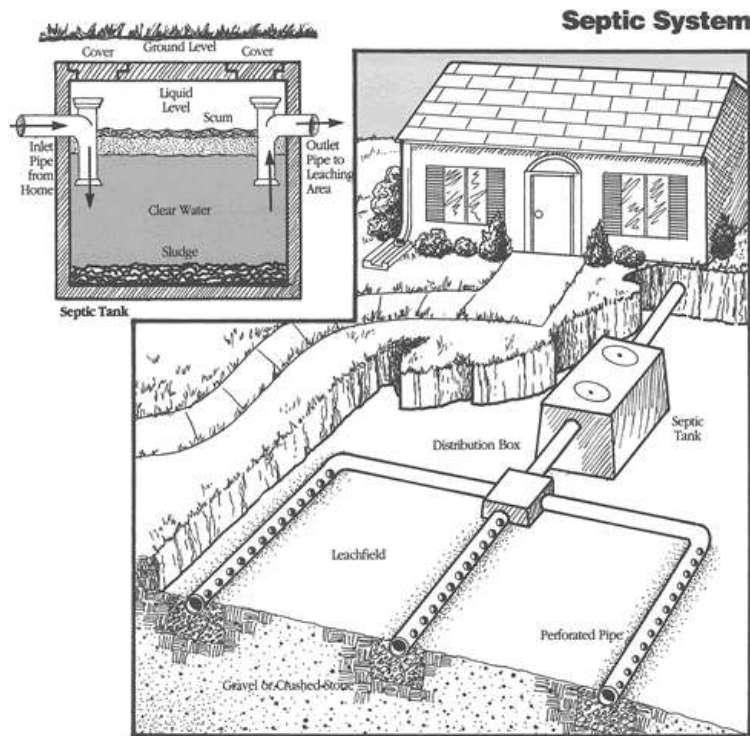
# Long-term nitrogen reduction strategies

Practice	Details	% Nitrate-N Reduction
Timing	Fall to Spring Pre-plant	6 (25)
	Spring pre-plant/sidedress 40-60 split compared to fall applied	5 (28)
	Sidedress – Soil test based compared to pre-plant	7 (37)
Nitrification Inhibitor	Nitrapyrin – Fall – Compared to applied w/out nitrapyrin	9 (19)
Cover Crops	Rye	31 (29)
	Oat	28 (2)
Perennial	Biofuel Crops (ex. switchgrass, miscanthus)	72 (23)
	Conservation Reserve Program	85 (9)
Extended Rotations	At least 2 years of alfalfa or other perennial crops in a 4 or 5 year rotation	42 (12)

[Iowa Nutrient Reduction Strategy, 2014](#)

Improve delivery and efficiency of nitrogen

# Septic systems and nitrate



Robertson and Harman 1999

- Designed to dispose of human waste in a manner that prevents bacteriological contamination of groundwater supplies.
- **Do not** effectively remove all contaminants from wastewater:  
**Nitrate, chloride, viruses?, pharmaceuticals?, hormones?**

# Comparing Land-use Impacts



	Corn <sup>1</sup> (per acre)	Prairie <sup>1</sup> (per acre)	Septic <sup>2</sup> System
Total Nitrogen Inputs (lb)	169	9	20-25
Nitrogen Leaching Loss (lb)	32	0.04	16-20
Amount N lost to leaching (%)	19	0.4	80-90

*1 Data from Masarik, 2014*

*2 Data from Tri-State Water Quality Council, 2005 and EPA 625/R-00/008*



# Comparing Land-use Impacts



20 acres

32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs

**32 lbs/ac x 20 acres = 640 lbs**  
**14 mg/L**



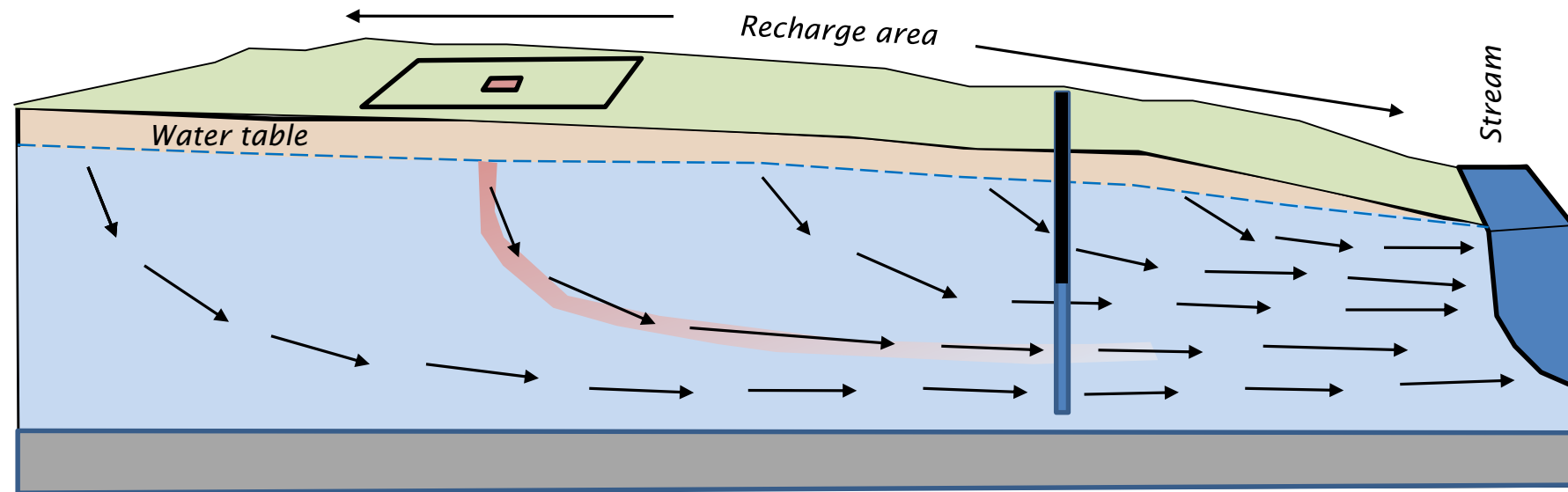
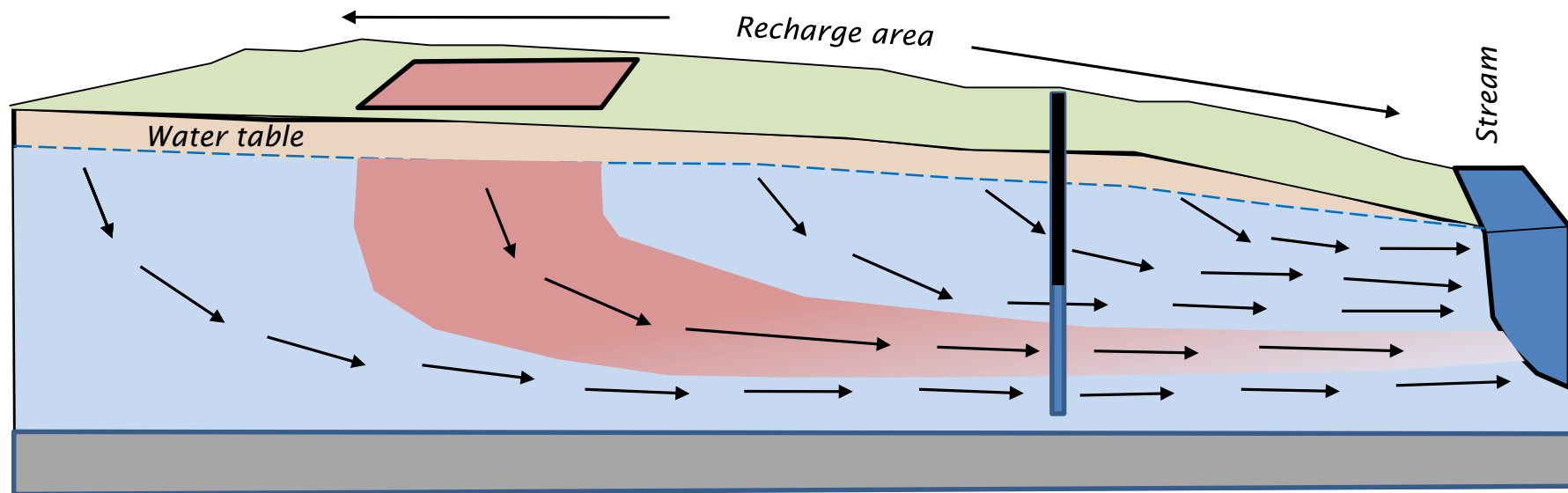
20 acres

20 lbs
--------

**20 lbs/septic system x 1 septic systems = 20 lbs**  
 1/32<sup>nd</sup> the impact on water quality  
**0.44 mg/L**

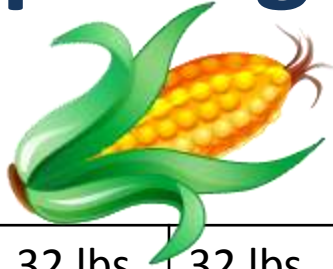
*Assuming 10 inches of recharge*

**32 lbs/ac x 20 acres = 640 lbs**



**20 lbs/septic system**

# Comparing Land-use Impacts



20 acres

32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs

20 acres

20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs

**32 lbs/ac x 20 acres = 640 lbs**

**20 lbs/septic system x 32 septic systems = 640 lbs**

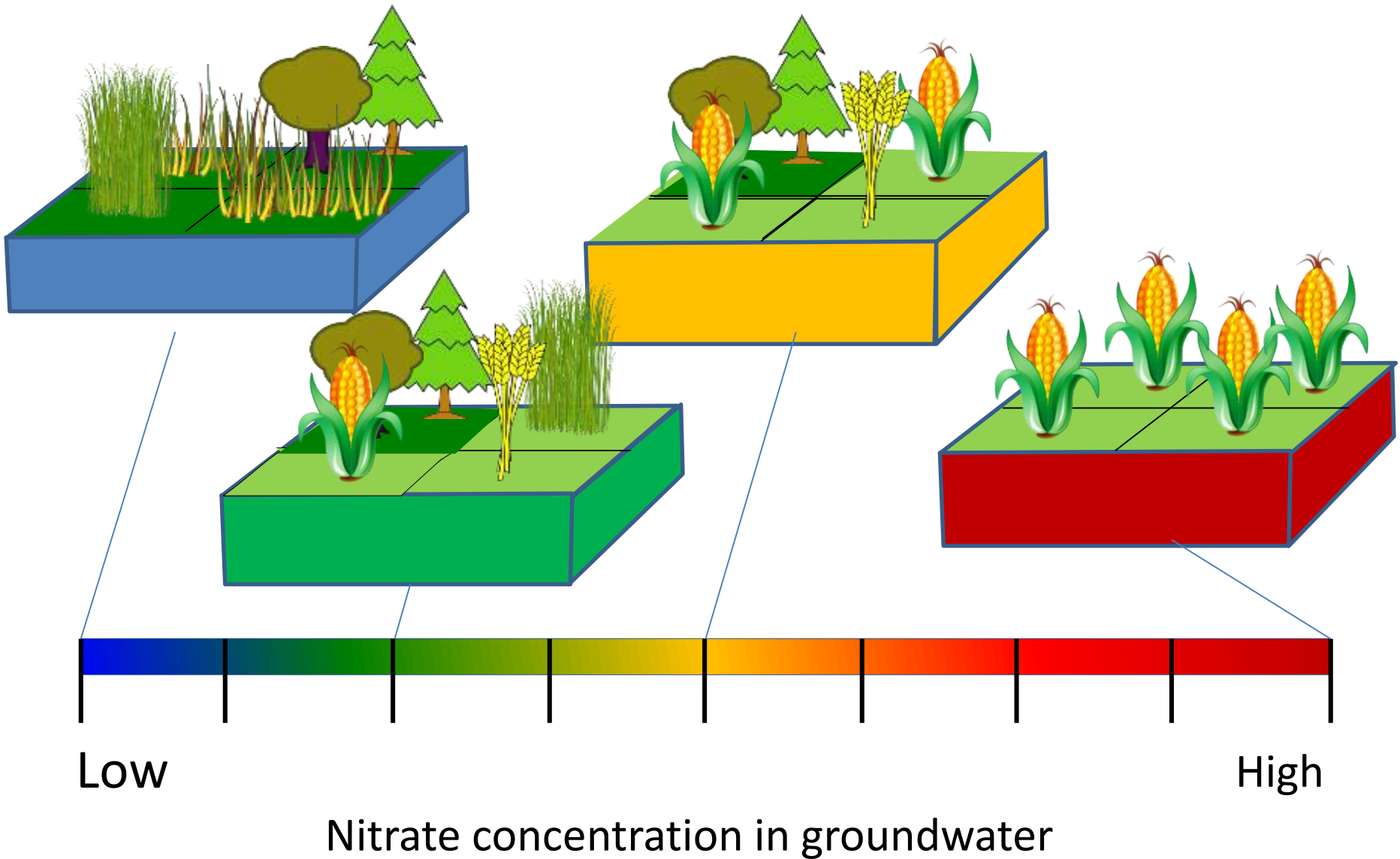
**Using these numbers:** 32 septic systems on 20 acres (0.6 acre lots) needed to achieve same impact to water quality as 20 acres of corn



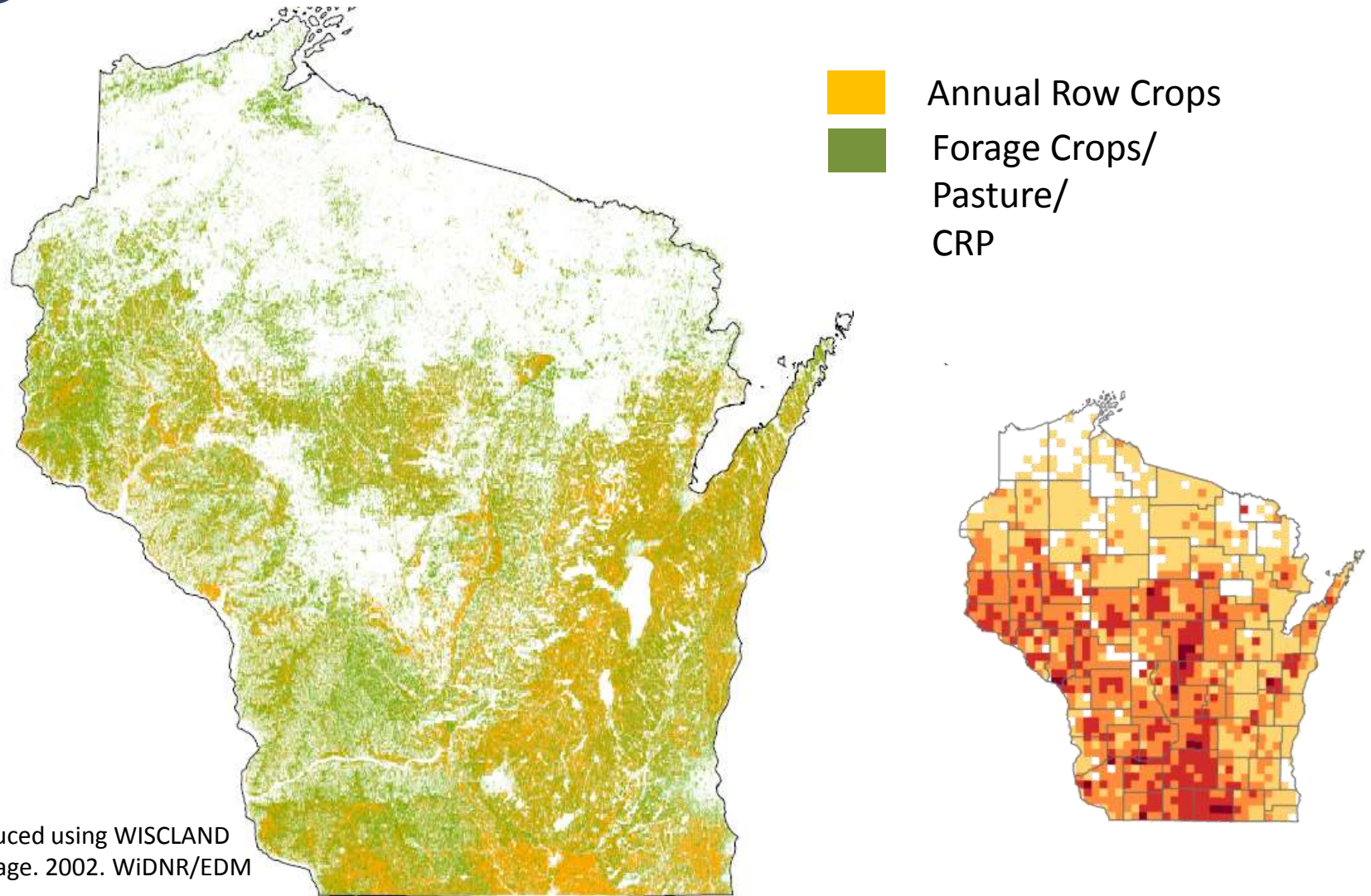




# Watershed land use portfolio



# Agricultural Lands of Wisconsin



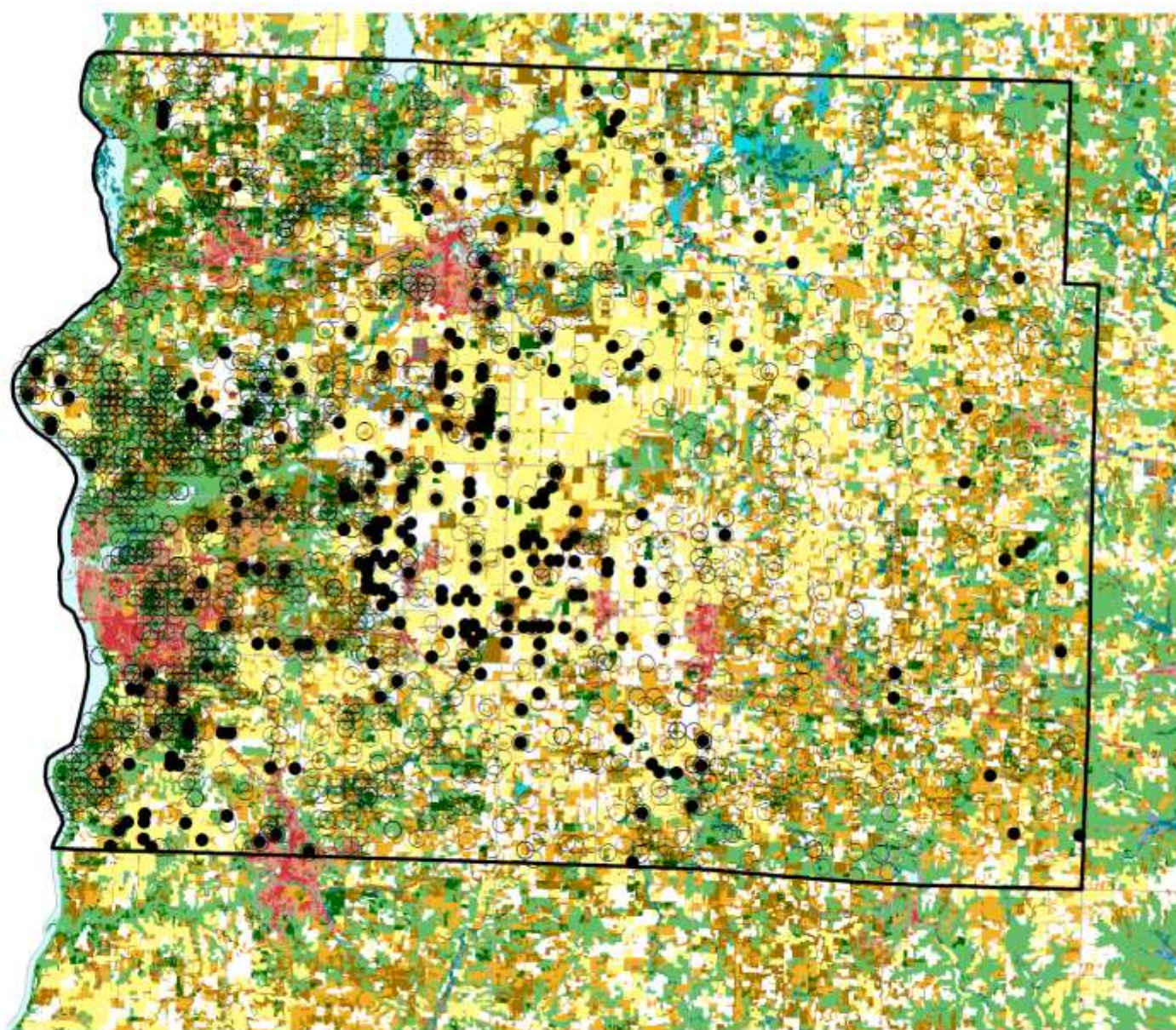


## Nitrate-Nitrogen Concentration (mg/L)

- Less than 2.0
- 2.0 to 10.0
- 10.1 - 20.0
- Greater than 20.0

## Land Cover

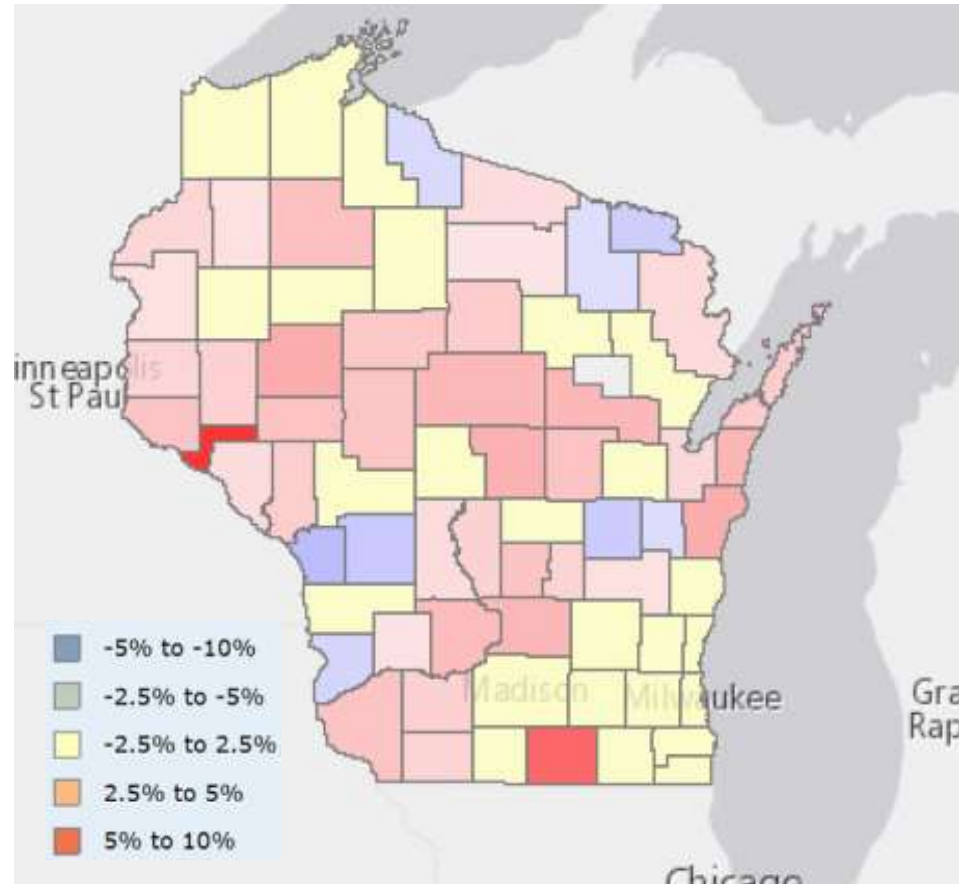
- Developed, High Intensity
- Developed, Low Intensity
- Cash Grain
- Continuous Corn
- Dairy Rotation
- Potato/Vegetable
- Cranberries
- Hay
- Pasture
- Cool-season Grass
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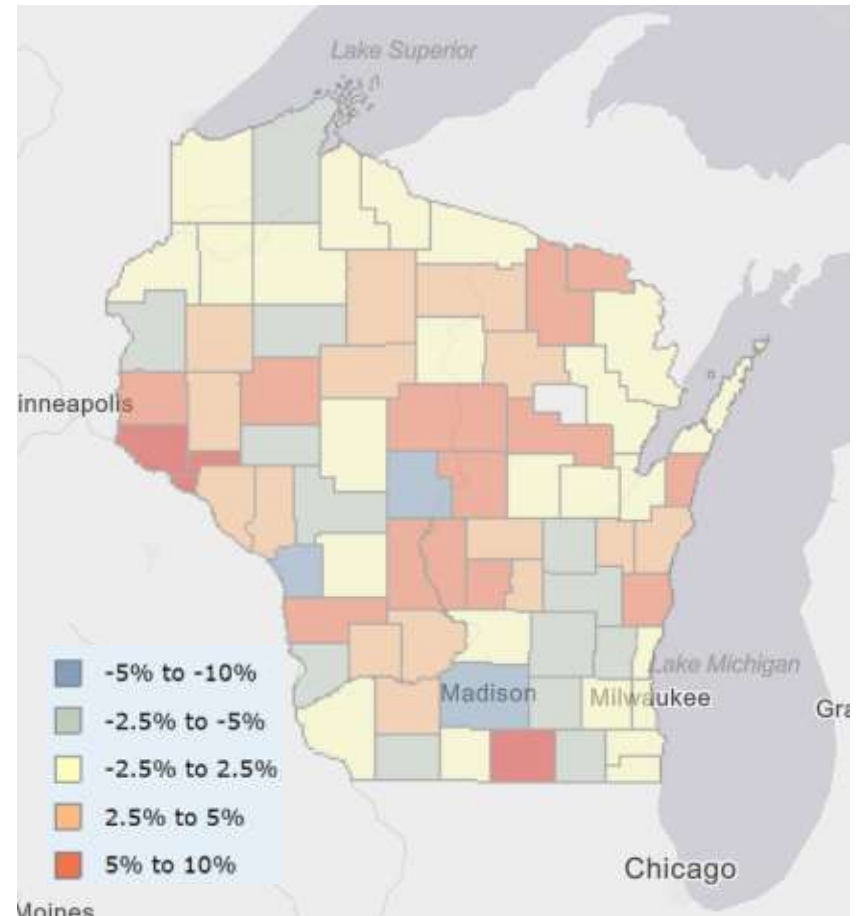
Disclaimer: Contains data from water testing performed at the Water and Environmental Analysis Lab through from 1988 through 2016. Does not represent all known wells. Land cover from Wiscland 2.0 coverage.



# Nitrate Trends by County



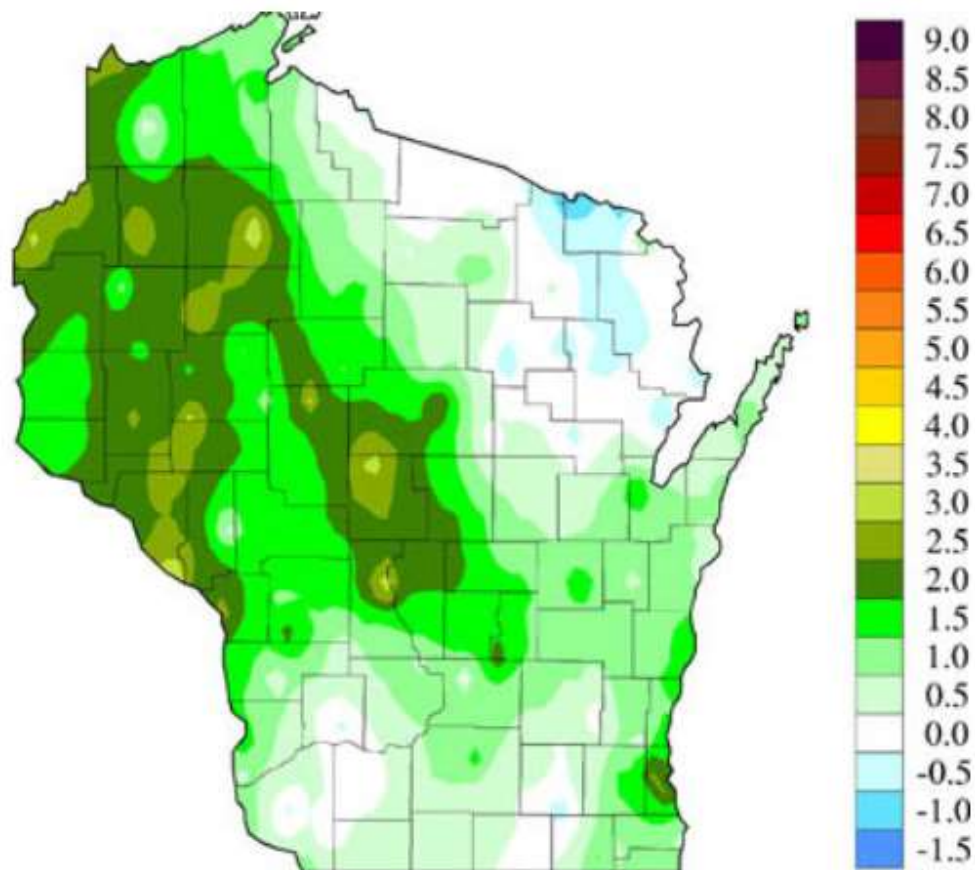
All TNC data, going back ~20 years



All TNC and NTNC systems  
limited to previous 10 years of  
data.

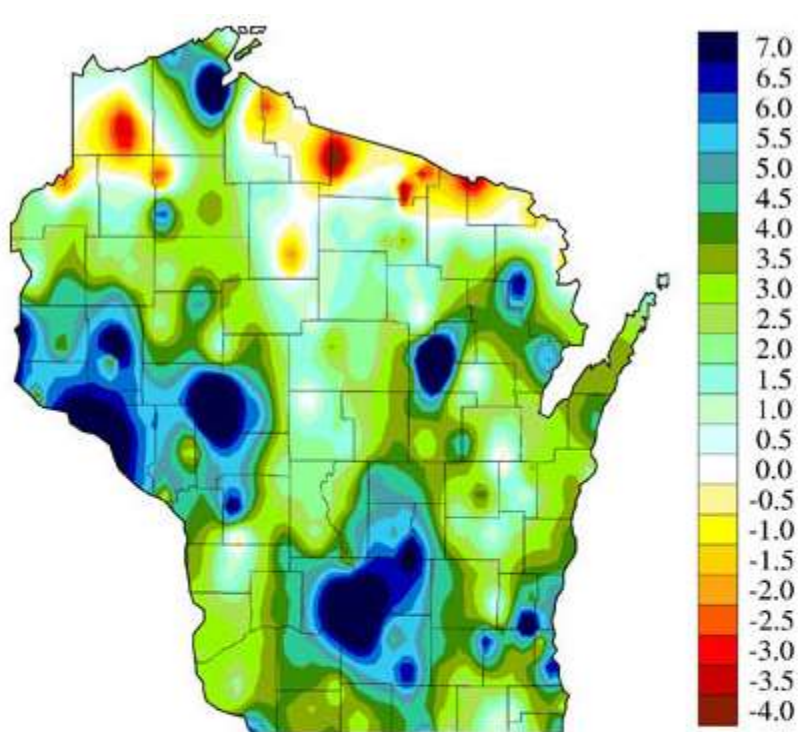
<http://dnr.wi.gov/topic/groundwater/GCC/gwquality.html>





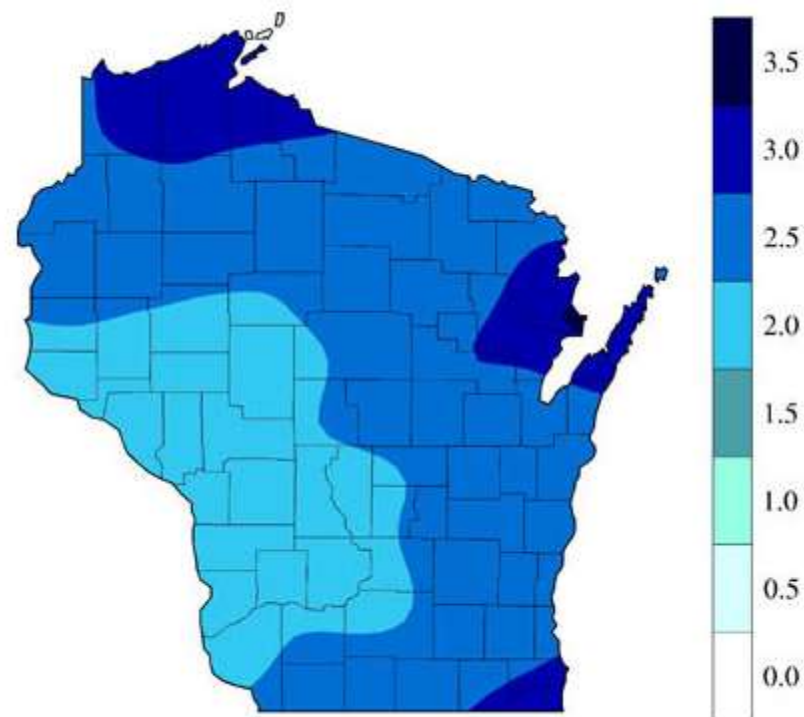
**Change in Annual Average Temperature (°F) from 1950 to 2006**

Except for northeastern Wisconsin, most of Wisconsin has warmed since 1950. Averaged across the state, the warming has been +1.1°F, with a peak warming of 2-2.5°F across northwest Wisconsin. Wisconsin is becoming "less cold", with the greatest warming during winter-spring and nighttime temperatures increasing.



### Change in Annual Average Precipitation (inches) from 1950 to 2006

From 1950 to 2006, Wisconsin as a whole has become wetter, with an increase in annual precipitation of 3.1 inches. This observed increase in annual precipitation has primarily occurred in southern and western Wisconsin, while northern Wisconsin has experienced some drying.



### Projected Change in the Frequency of 2" Precipitation Events (days/decade) from 1980 to 2055

Typically, heavy precipitation events of at least two inches occur roughly 12 times per decade (once every 10 months) in southern Wisconsin and 7 times per decade (once every 17 months) in northern Wisconsin. Based on one emission scenario, by the mid-21st century, Wisconsin may receive 2-3 more of these extreme events per decade, or roughly a 25% increase in their frequency.



Contact Info:

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Stevens Point, WI 54481

715-346-4276

kmasarik@uwsp.edu  
www.uwsp.edu/cnr/watersheds

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COUNTLESS POSSIBILITIES.**



**University of Wisconsin-Stevens Point**  
College of Natural Resources

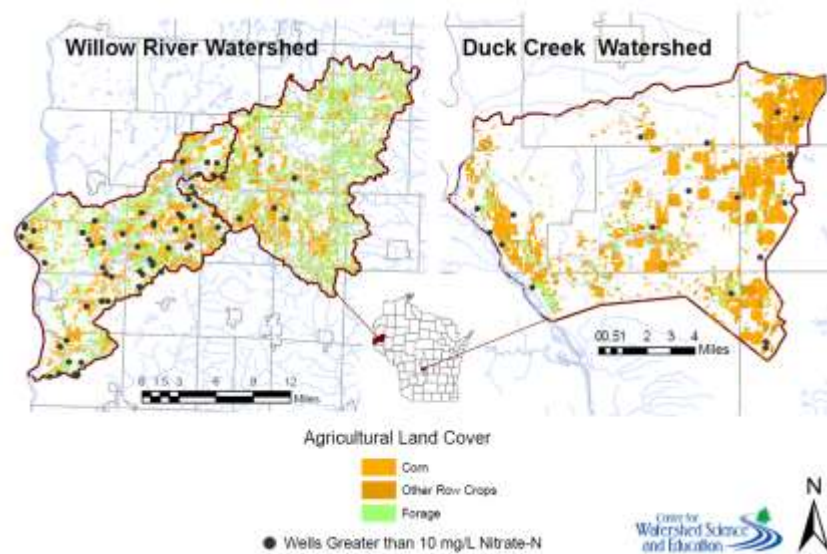
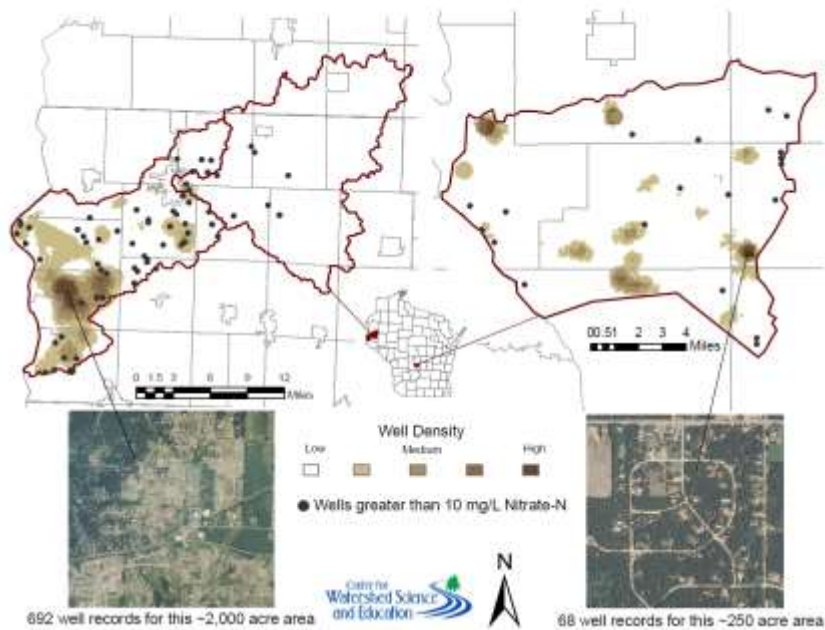
# Reason for nitrate trends

- **Shallow groundwater**
  - Change in land use
- **Deeper groundwater/  
rivers and streams**
  - Lag time between land use and groundwater



<http://www.youtube.com/watch?v=BKrN2HdvGp4>





## How Manure Composition Affects N Mineralization

The rate of mineralization in soil depends upon the "digestibility" of manure organic matter and its carbon:nitrogen (C:N) ratio. Separation of whole manure into liquids and solids segregates coarse and fine manure particles that have different organic composition and different mineralization rates. Fine particles in manure contain organic compounds with low C:N ratios (high protein) and are rapidly decomposed in soil. Coarse particles have higher C:N ratios (lower protein) and are more slowly decomposed in soil.

Because thin slurry and lagoon water contain the finest organic particles, these materials have the most rapid N mineralization rate. Thick slurry and solid manures contain a mixture of fine and coarse particles, so they have a lower N mineralization rate.

Solids separated from liquid manure by a mechanical separator (separated dairy solids) contain mostly coarse particles (bedding plus undigested feed). These solids have a unique pattern of mineralization over time in soil. Separated solids typically have negative N mineralization rates (PAN in soil decreases) for 4 to 8 weeks after application. After that, PAN is mineralized very slowly. Cumulative PAN from separated solids is much lower than for other fresh manures. The timing and amount of PAN release from horse manure is similar to that from separated dairy solids.

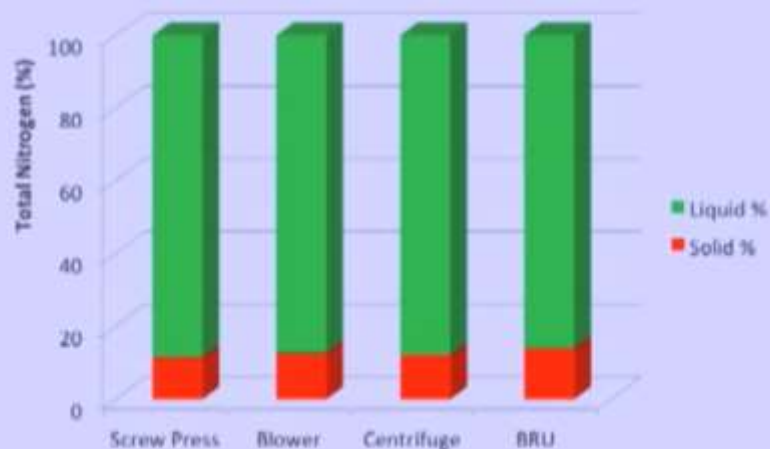
Separation of solids from liquid manure by gravity separation (settling basin or evaporation basin) does not change PAN, because the fine organic particles in the manure are recovered from the basin.

Composting manure reduces manure volume by 50 percent or more. During composting, some of the manure N is lost as ammonia gas, and some is transformed to more stable organic compounds. Compost organic matter decomposes very slowly in soil. Cumulative PAN for compost organic matter is similar to that of separated dairy solids.

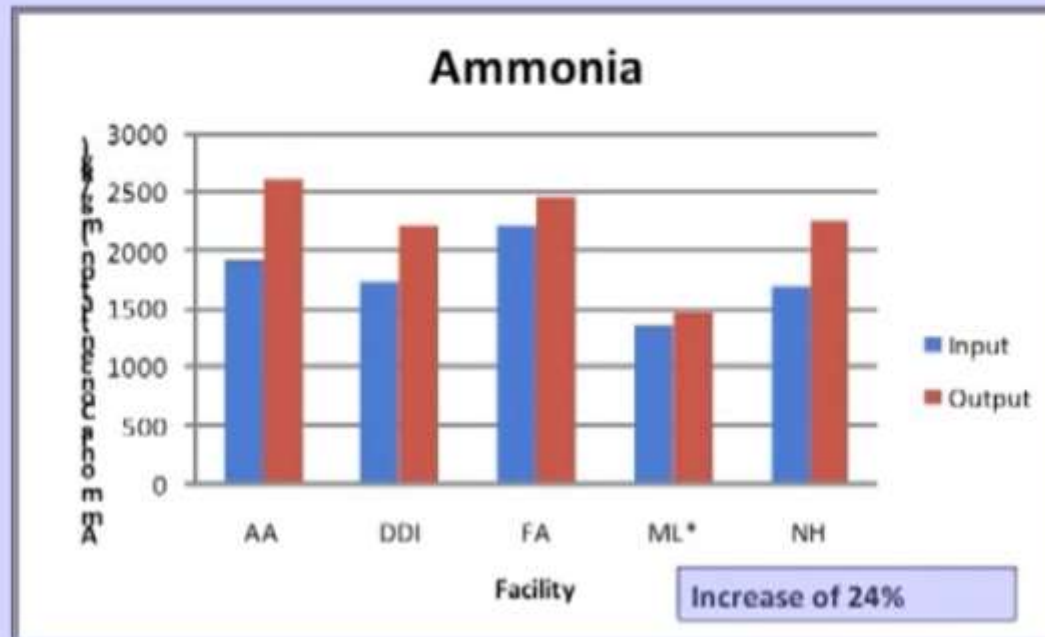
Fresh poultry manure or broiler litter contains some organic N in the form of uric acid (similar to urea). In soil, uric acid is converted to PAN in 1 to 2 weeks. Most broiler litter sold as "compost" in western Oregon contains uric acid and behaves more like fresh litter than compost in terms of N availability. If you can smell ammonia in broiler litter, it probably is not thoroughly composted. Dry-stacking of broiler litter does not provide adequate moisture for composting.

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## Total Nitrogen



# Nutrients & Anaerobic Digestion

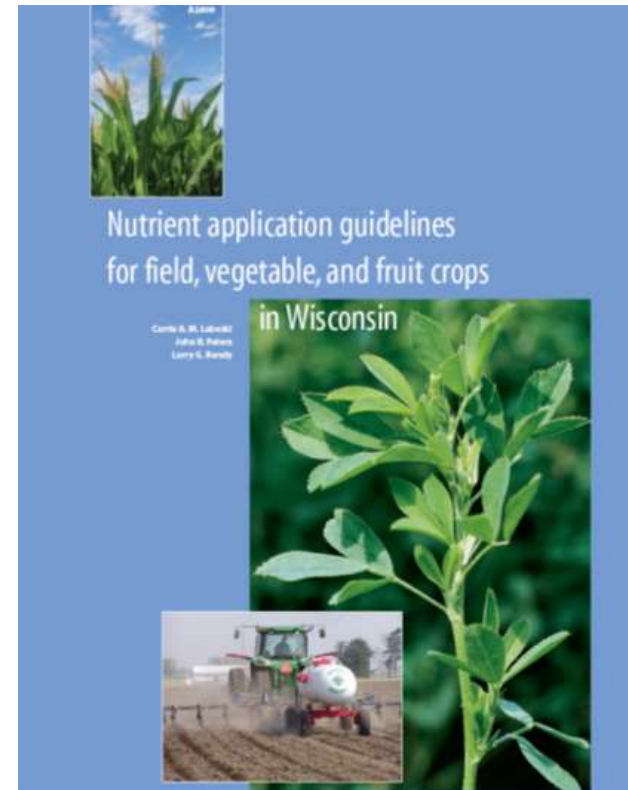


Wright, et al. 2004. Preliminary Comparison of Five Anaerobic Digestion Systems on Dairy Farms in New York State

Slide from presentation by Becky Larson, Manure Irrigation Workshop

# What UWEX Nutrient Guidelines Do and Don't Do:

- **Do** save farmers money by ensuring nitrogen is used efficiently
- **Do** allow farms to maximize profitability while holding everyone accountable to some standard
- **Do** prevent fields from being treated as dumping grounds for manure and other bio-solids
- **Do** help prevent excessively high concentrations of nitrate in groundwater
- **Don't** prevent nitrate from leaching into groundwater
- **Don't** ensure groundwater quality meets drinking water standards
- **Don't** ensure that groundwater quality in areas that already apply at economic optimum rates will get better over time



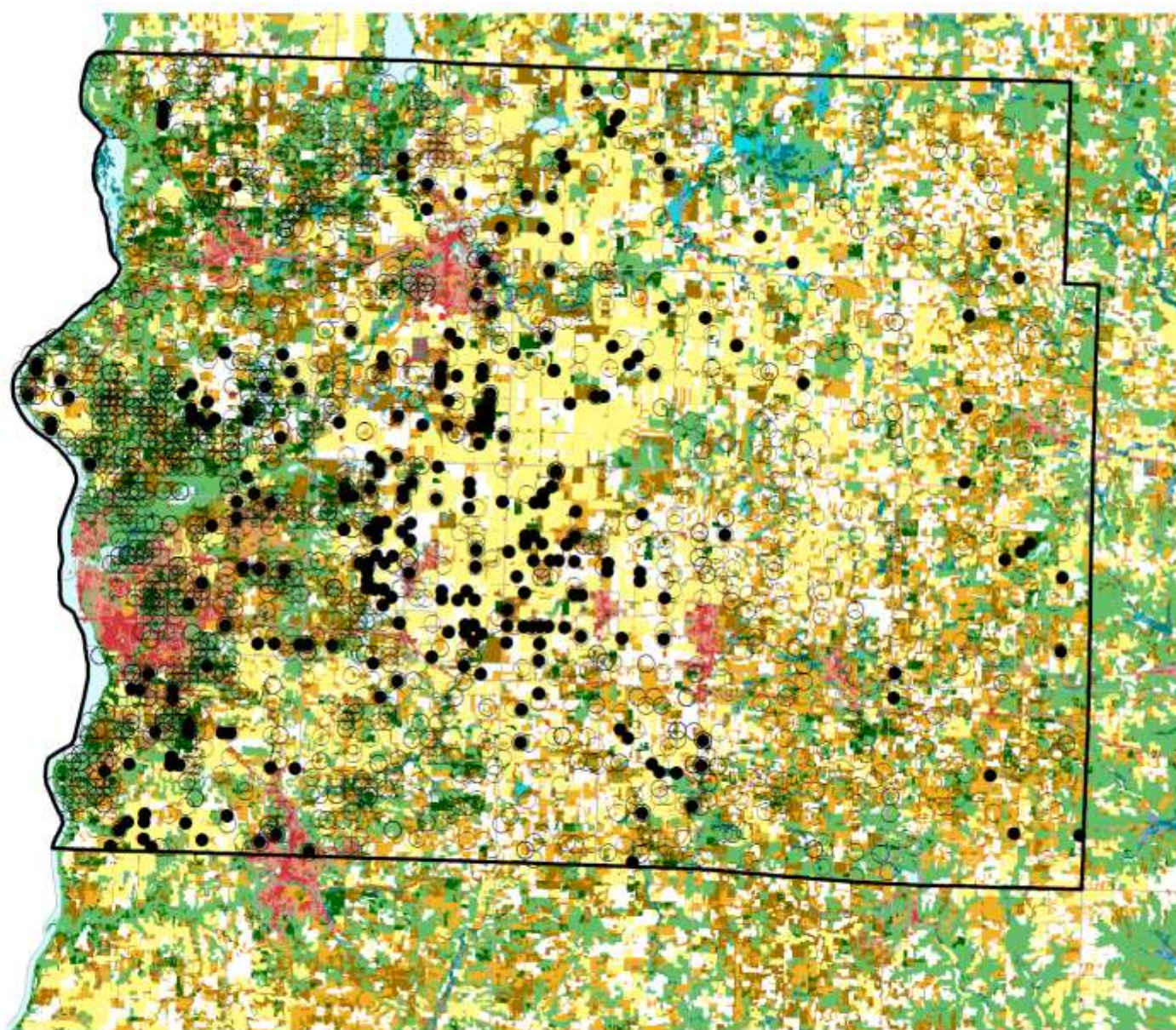


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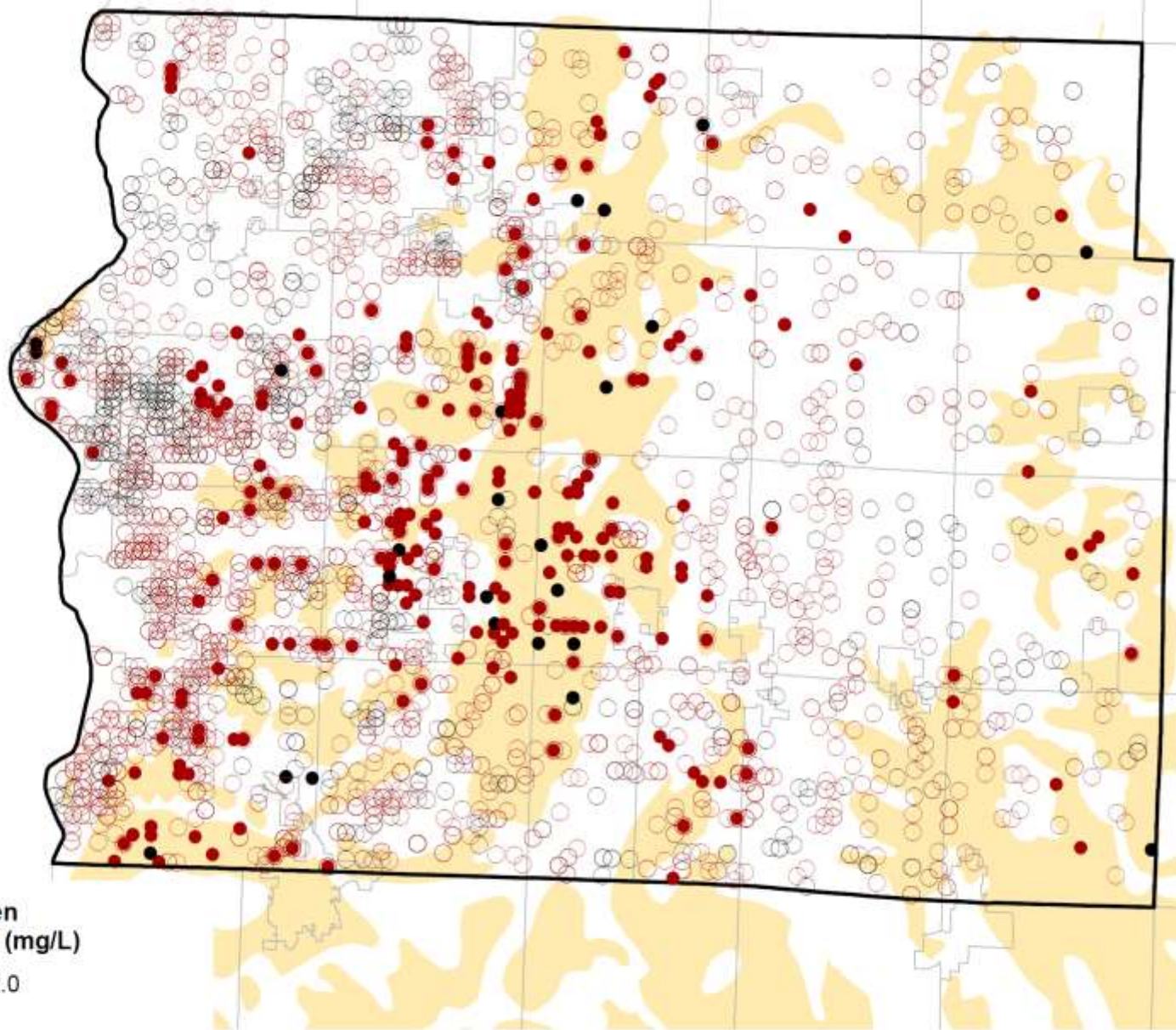
## Land Cover

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- Continuous Corn
- Dairy Rotation
- Potato/Vegetable
- Cranberries
- Hay
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